INSTRUCTION MANUAL

MODEL 100AH
SULFUR DIOXIDE ANALYZER
HIGH LEVEL

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SAFETY MESSAGES

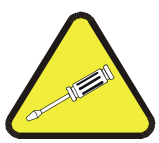
Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:

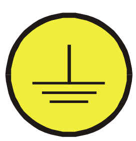
GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.

CAUTION: Hot Surface Warning

CAUTION: Electrical Shock Hazard



TECHNICIAN SYMBOL: All operations marked with this symbol are to be performed by qualified maintenance personnel only.



ELECTRICAL GROUND: This symbol inside the instrument marks the central safety grounding point for the instrument.

CAUTION

The analyzer should only be used for the purpose and in the manner described in this manual.

If you use the analyzer in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

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LIST OF FIGURES

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1 HOW TO USE THIS MANUAL

The Model 100AH has been designed with serviceability, reliability and ease of operation in mind. The M100AH's microprocessor continually checks operating parameters such as temperature, flow, and critical voltages. The instruments modular design uses captive screws to facilitate repair and ease of access. If you encounter any difficulty refer to Section 10 General Troubleshooting Hints.

We recognize that the need for information in this manual changes as time passes. When the instrument first arrives, it is necessary to get it up and running quickly and verify its correct operation. As time passes, more detailed information is often required on special configurations, calibration alternatives and other operational details. Finally there is the need for periodic maintenance and to quickly troubleshoot problems to assure maximum uptime and data integrity.

To address these needs, we have created three indexes to the information inside. They are:

Table of Contents:

Outlines the contents of the manual in the order the information is presented. This is a good overview of the topics covered in the manual. There is also a list of Tables and a list of Figures.

Index to M100AH Front Panel Menus:

The Menu Index (Figure 5-1, Figure 5-2 and Table 5-2) briefly describes the front panel menus and refers you to other sections of the manual that have a detailed explanation of each menu selection.

Troubleshooting Section 10:

The Troubleshooting Section, outlined in the Table of contents, allows you to diagnose and repair the instrument based on variables in the TEST menu, the results of DIAGNOSTIC tests, and performance faults such as excessive noise or drift. The troubleshooting section also explains the operation, adjustment, diagnosis and testing of each instrument subsystem.

If you are unpacking the instrument for the first time, please refer to Getting Started in Section 2.

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2 GETTING STARTED

2.1 Installation

CAUTION

To avoid personal injury, always use two persons to lift and carry the Model 100AH.

1. Verify that there is no apparent shipping damage. If damage has occurred please advise shipper first, then Teledyne API.
2. Before operation it is necessary to remove the shipping hold-down screws. Remove the instrument cover, then refer to Figure 2-1 for screw location.

NOTE

Save these shipping screws and re-install then whenever the unit is shipped to another location.

3. While the instrument cover is removed, please check the voltage and frequency label on the cover of the power supply module and compare that to your local power before plugging in the M100AH.
4. Check for internal shipping damage, and generally inspect the interior of the instrument to make sure all circuit boards and other components are in good shape.
5. Replace the instrument cover.
6. When installing the M100AH, allow at least 4” (100 mm) clearance at the back and at least 1” (25 mm) clearance at each side for proper venting.

2.2 Electrical and Pneumatic Connections

1. Refer to Figure 2-2 to locate the rear panel electrical and pneumatic connections.
2. The pressure of the sample gas at the inlet port should be at atmospheric pressure (±2"Hg). Refer Figure 2-3 and Figure 8-1 for pneumatic system connection.
3. Attach the pump to the "Exhaust Out" port on the instrument rear panel. The exhaust from the pump also should be vented to a suitable vent at atmospheric pressure. (See Figure 2-3 for exhaust line venting recommendations.)
4. If desired, attach the analog output connections to a strip chart recorder and/or datalogger. Non-isolated 4-20mA current output is standard. Each 4-20 mA current output should be connected to one interfacing device only.
5. Connect the power cord to the correct voltage line, then turn to Section 2.3 Initial Operation.

WARNING – Analyzer Exhaust

Danger – Analyzer exhaust may contain high concentration of SO_2 gas. Exhaust properly from the pump pack exhaust to well ventilated area at atmospheric pressure.

CAUTION

High voltages present inside case.

DO NOT LOOK AT THE UV LAMP.

UV LIGHT COULD CAUSE EYE DAMAGE.

**ALWAYS USE SAFETY GLASSES
(PLASTIC GLASSES WILL NO DO).**

Connect the exhaust fitting of the pump to a suitable vent outside of the room.

CAUTION

Do not operate with cover off.

Before operation check for correct input voltage and frequency on serial number sticker.

Do not plug in the power cord if the voltage or frequency is incorrect.

Do no operate without proper chassis grounding.

Do not defeat the ground wire on power plug.

Turn off analyzer power before disconnecting or connecting electrical subassemblies.

Always replace shipping screws when transporting the Analyzer.

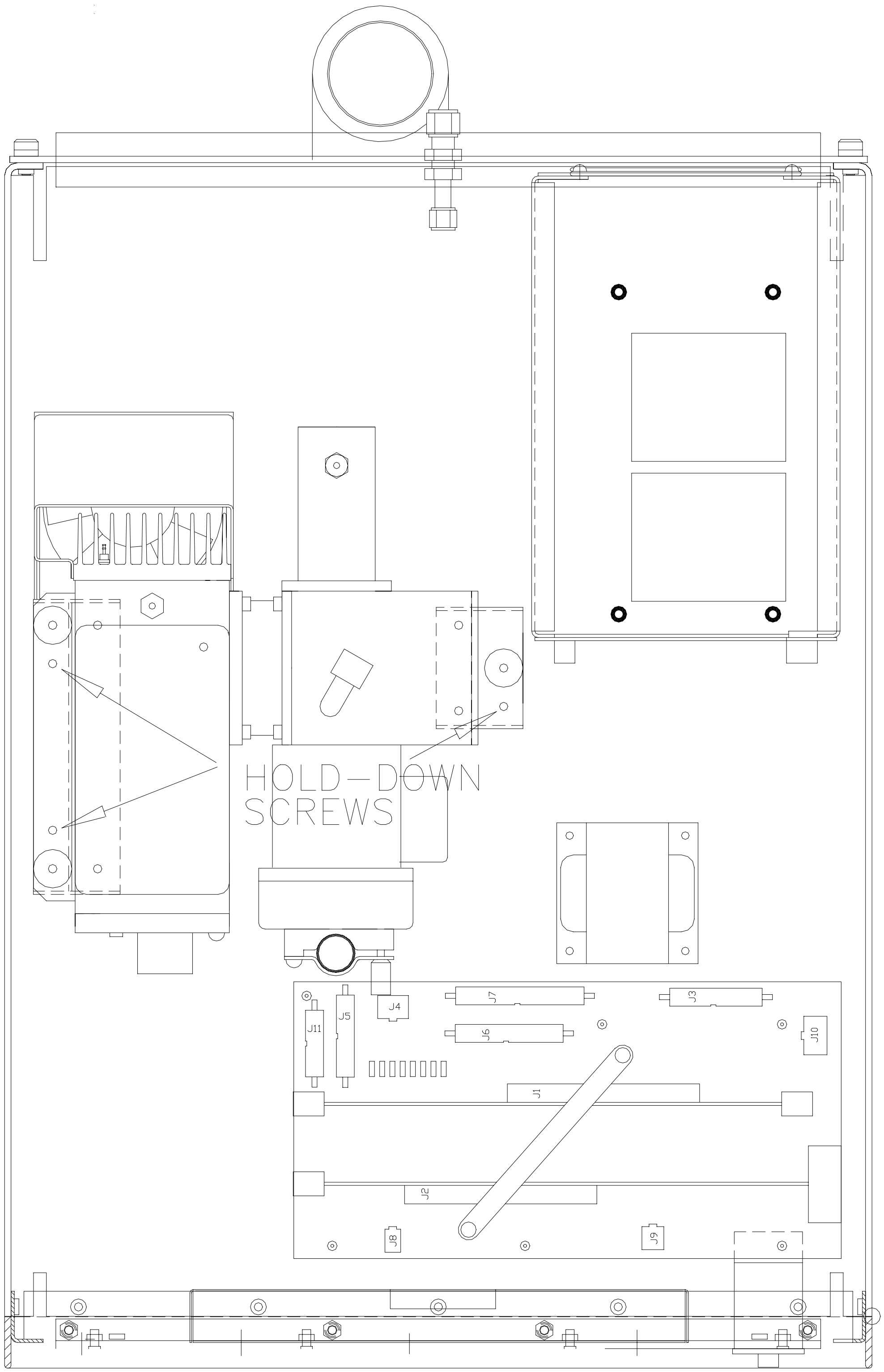
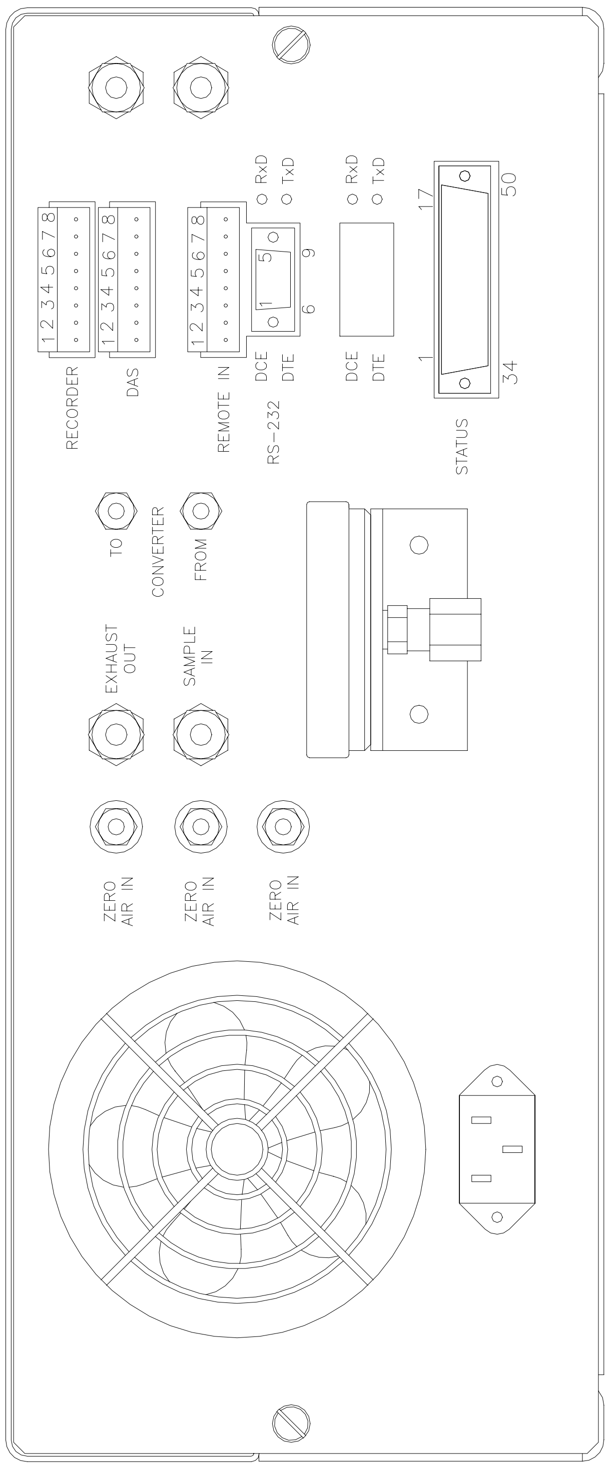


Figure 2-1: Removal of Shipping Screws



RECORDER AND DAS PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	+ SO2(RANGE1)
2	− SO2(RANGE1)
3	+ SO2(RANGE2)
4	− SO2(RANGE2)
5	
6	
7	+ TEST CHANNEL
8	− TEST CHANNEL

REMOTE IN PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	+ REM ZERO CAL
2	− GND
3	+ REM SPAN HI
4	− GND
5	+ REM SPAN LO
6	+ SPARE INPUT
7	+ SPARE INPUT
8	+ SPARE INPUT

RS-232 PORT PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	
2	*TX(RX) DATA
3	*RS(TX) DATA
4	
5	SIG GROUND
6	DSR
7	
8	CTS
9	

*Jumpers set inter-changeable

Figure 2-2: Rear Panel

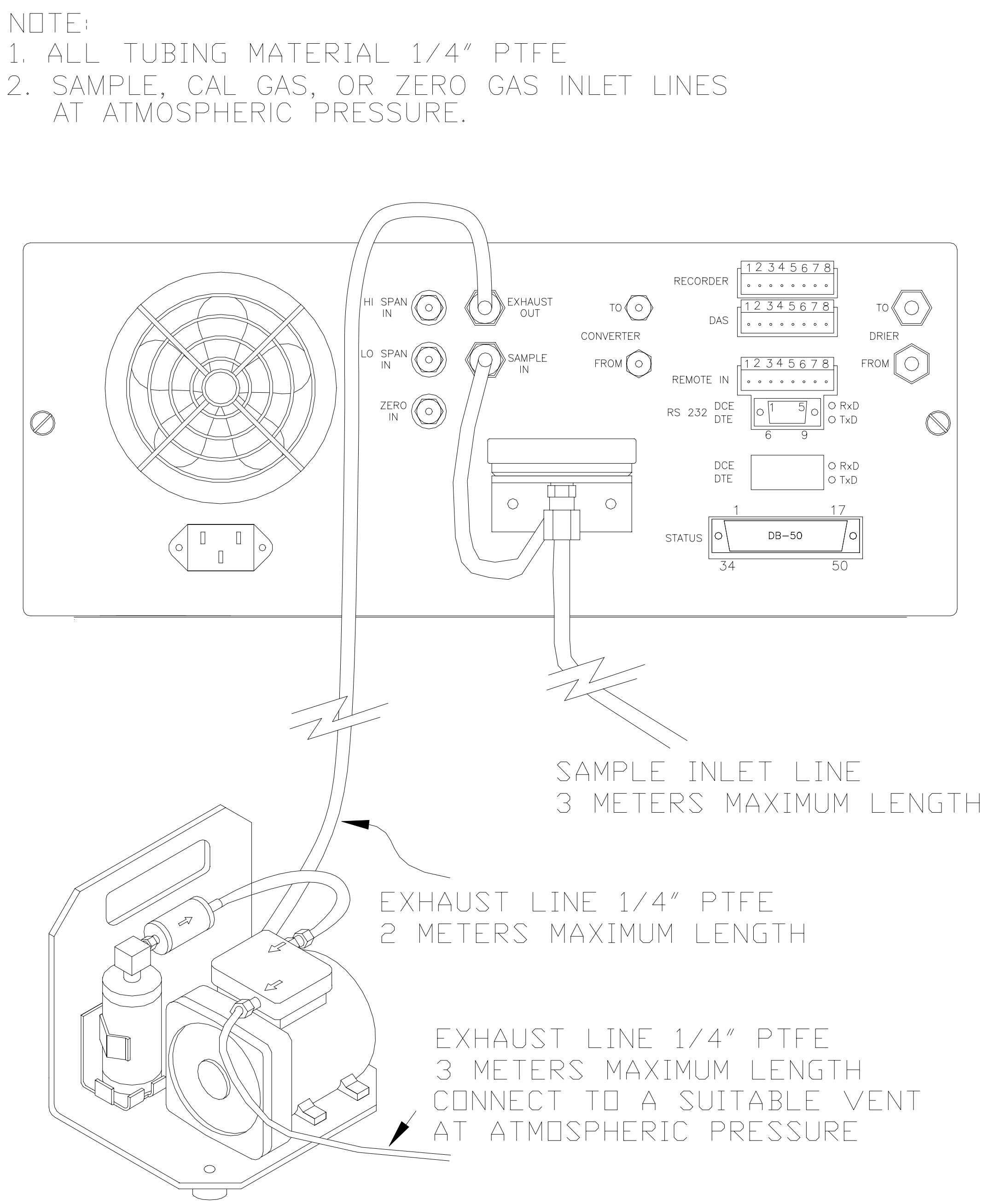


Figure 2-3: Rear Panel Pneumatic Recommendations

2.3 Initial Operation

1. Turn on the instrument power.
2. The display should immediately light, displaying the instrument type (M100AH) and the CPU memory configuration. If you are unfamiliar with the M100AH, we recommend that you read the overview Section 4 before proceeding. A diagram of the software menu trees is in Figure 5-1 and Figure 5-2.
3. The M100AH requires about 30 minutes for all internal components to come up to temperature.
4. While waiting for instrument temperatures to come up, you can check for correct operation by using some of the M100AH's diagnostic and test features.
5. Examine the TEST functions by comparing the values listed in Table 2-1 to those in the display. Remember that as the instrument warms up the values may not have reached their final values yet. If you would like to know more about the meaning and utility of each TEST function refer to Table 10-1. Table 2-1 also contains the list of options. Section 6 covers setting up the options.
6. When the instrument is warmed up, re-check the TEST functions against Table 2-1. All of the readings should compare closely with those in the Table. If they do not, see Section 10.1.1.

The next task is to calibrate the analyzer. There are several ways to do a calibration; they are summarized in Table 7-1. For a preliminary checkout we recommend calibration with zero air and span gas coming in through the sample port. The procedure is:

WARNING – Analyzer Exhaust

Danger – Analyzer exhaust may contain high concentration of SO_2 gas. Exhaust properly from the pump pack exhaust to well ventilated area at atmospheric pressure.

Step 1 - Enter the expected SO_2 span gas concentration:

Step Number	Action	Comment
1.	Press CAL-CONC	This key sequence causes the M100AH to prompt for the expected SO_2 concentration. Enter the SO_2 span concentration value by pressing the key under each digit until the expected value is set.
2.	Press ENTR	ENTR stores the expected SO_2 span value. This value will be used in the internal formulas to compute subsequent SO_2 concentration values.
3.	Press EXIT	Returns instrument to SAMPLE mode.
4.	Press SETUP-RNGE-SET	If necessary you may want to change ranges. Normally the instrument is shipped in single range mode set at 500 PPM. (see Section 5.3.4 for Range Menu)
5.	Press EXIT	Returns the instrument to SAMPLE mode.

Step 2 - Calibrate the instrument:

Initial Zero/Span Calibration Procedure

Step Number	Action	Comment
1.	Input Zero gas	Allow Zero gas to enter the sample port on the rear of the instrument.
2.	Press CAL	The M100AH enters the calibrate mode from sample mode.
3.	Wait 5 - 10 min	Wait for reading to stabilize at the zero value. (If you wait less than 5 - 10 minutes the final zero value may drift.)
4.	Press ZERO	The ENTR button will be displayed.
5.	Press ENTR	Pressing ENTR actually changes the calculation equations and zeroes the instrument.
6.	Press EXIT	M100AH returns to the CAL menu. Allow SPAN gas to enter the sample port on the rear of the instrument.
7.	Wait 5 - 10 min	Wait for reading to stabilize at the span value. (If you wait less than 5 -10 minutes the final span value may drift.)
8.	Press SPAN	If SPAN button is not displayed, check the Troubleshooting Section 10.2.8 for instructions on how to proceed. In certain circumstances at low span gas concentrations (<100PPM), both the ZERO and SPAN buttons will appear. This is acceptable and just do not press ZERO button.
9.	Press ENTR	Pressing ENTR actually changes the calculation equations so that the concentration displayed is the same as the expected span concentration you entered above, thus spanning the instrument.
10.	Press EXIT	Pressing EXIT returns the instrument to SAMPLE mode.

Step 3 - Review the quality of the calibration:

Calibration Quality Check Procedure

Step Number	Action	Comment
1.	Scroll the TEST function menu until SLOPE is displayed.	Typical SLOPE value is 1.0 ± 0.3. If the value is not in this range, check Section 8.7 or 10. If the SLOPE value is in the acceptable range the instrument will perform optimally.
2.	Scroll the TEST function menu until OFFSET is displayed.	The M100AH will display the OFFSET parameter for the SO_2 equation. A value less than 200mV indicates calibration in the optimal range. If the OFFSET value is outside this range, check Section 8.7 and 10.

Step 4 - The M100AH is now ready to measure sample gas.

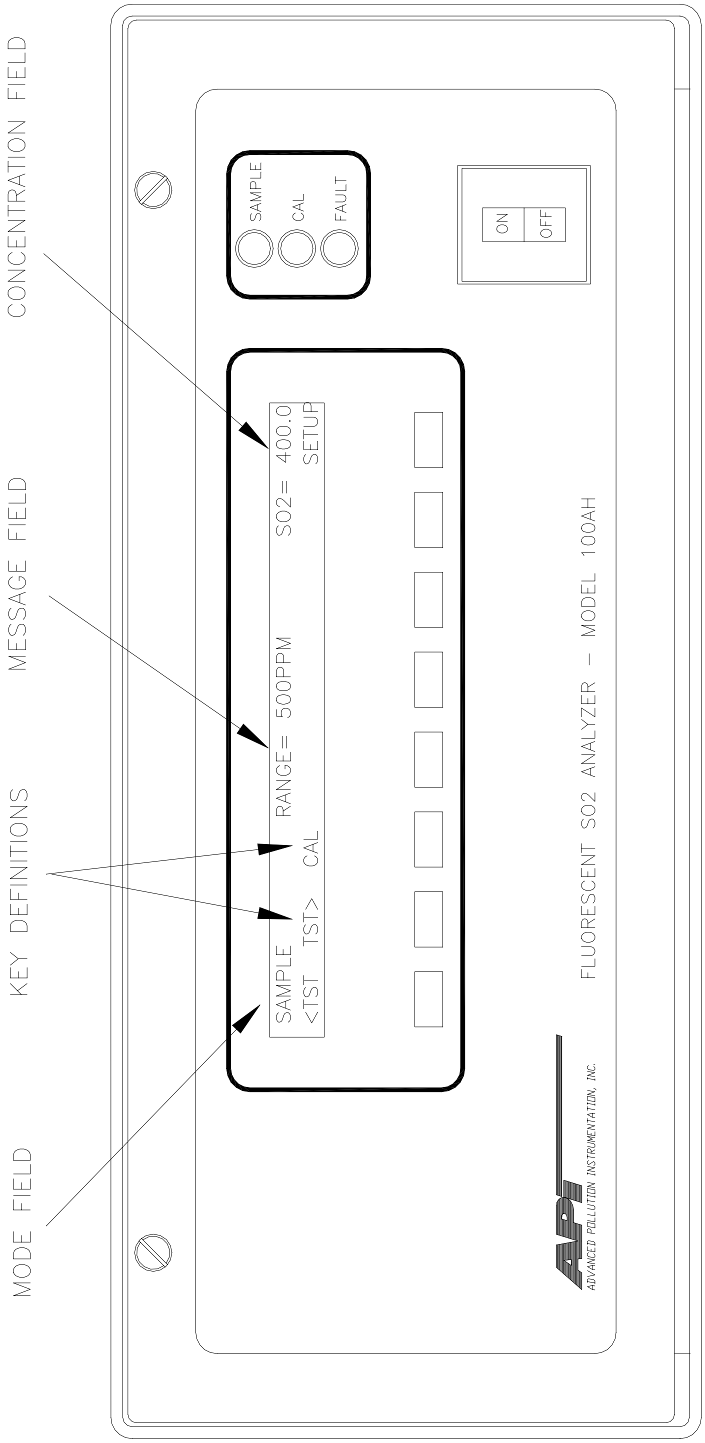


Figure 2-4: Front Panel

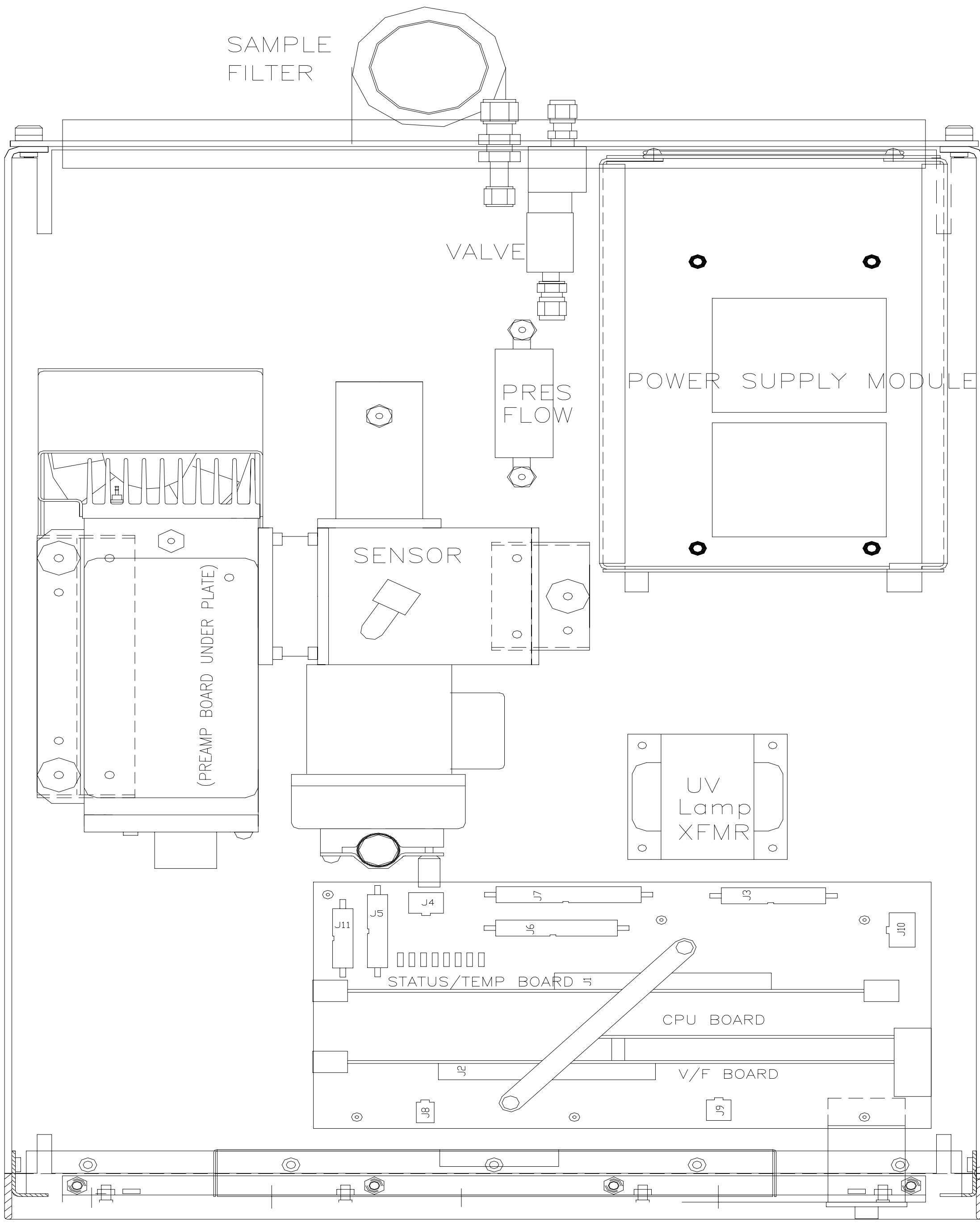


Figure 2-5: Assembly Layout

Table 2-1: Final Test and Calibration Values

Test Values	Observed Value	Units	Nominal Range	Reference Section
RANGE		PPM	10 - 5000	5.3.4
STABIL		PPM	0.01 - 0.05	5.2.1, 10.1.1, 10.2.5, Table 10-1
INLET SAMPLE PRESS		in-Hg-Abs	25 - 35	10.1.1, 10.3.5, Table 10-1
VACUUM PRESS		in-Hg-Abs	4 - 10	10.3.5, Table 10-1
SAMP FL		CC / MIN	650 ± 60	10.2.2, 10.3.5, Table 10-1
PMT		mV	0 - 5000	10.4.1
UV LAMP		mV	2000 - 4000 typical	10.4.2
STR. LGT		PPM	<100.0	Table 10-1
DARK PMT		mV	<200	Table 10-1
DARK LAMP		mV	<200	Table 10-1
SLOPE			1.0 ± 0.3	8.7
OFFSET		mV	<200	8.7
HVPS		V	450 - 900 constant	10.3.9
DCPS		mV	2500 ± 200	10.3.4
RCELL TEMP		°C	50 ± 1	10.3.6
BOX TEMP		°C	8 - 50	10.3.3.1
PMT TEMP		°C	7 ± 1	10.3.8
Electric Test & Optic Test				
Electric Test				
PMT Volts		mV	2000 ± 100	10.1.3.2
SO_2 Conc		PPM	2000 ± 100	10.1.3.2
Optic Test				
PMT Volts		mV	200 ± 20	10.1.3.3
SO_2 Conc		PPM	200 ± 20	10.1.3.3

Table 2-1: Final Test and Calibration Values (Continued)

Parameter	Observed Value	Units	Nominal Range	Reference Section
Span and Cal Values				
SO_2 Span Conc		PPM	100 - 4500	Table 8-3
SO_2 Slope			1.0 ± 0.3	8.7
SO_2 Offset		mV	<100	8.7
Noise at Zero (rms)		PPM	0.05 - 0.2	Table 10-1
Noise at Span (rms)		PPM	0.5% of reading (above 50PPM)	Table 10-1
Measured Flows				
Sample Flow		cc/min	650 ± 60	10.2.2, 10.3.5, Figure 10-5
Factory Installed Options			**Option Installed**	
Power Voltage/Frequency				
Rack Mount, w/ Slides				
Rack Mount, w/ Ears Only				
Zero/Span Valves Manifold				
Multi-drop				
Kicker				
37 mm Filter				
4-20 mA Isolated Current Loop Output (non-isolated standard)			ISOLATED	NON-ISOLATED
SO_2 (RANGE 1)			____________	____________
SO_2 (RANGE 2)			____________	____________
SPARE			____________	____________
TEST OUTPUT			____________	____________

PROM # ______________________________ Serial # ______________________________

Date ______________________________ Technician ______________________________

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3 SPECIFICATIONS, AGENCY APPROVALS, WARRANTY

3.1 Specifications

Ranges	In 1 PPM increments from 10 PPM to 5000 PPM, dual ranges or autoranging
Noise at Zero	0.05 PPM RMS
Noise at Span	<0.5% of reading (above 50 PPM)
Lower Detectable Limit[1]	0.1 PPM RMS
Zero Drift[2]	< 1 PPM/24 hours
Zero Drift[2]	<2 PPM/7 days
Span Drift[2]	<0.5% FS/7 days
Lag Time	5 sec
Rise Time	95% in < 30 sec
Fall Time	95% in < 30 sec
Sample Flow Rate	650cc/min. ±10%
Linearity	1% of full scale
Precision	0.5% of reading
Temperature Range	5 - 40°C
Temp Coefficient	< 0.1% per °C
Humidity	0 - 95% RH, non-condensing
Voltage Coefficient	< 0.05% per V
Dimensions HxWxD	7"x17"x23.6" (18 cm x 43 cm x 61 cm)
Weight, Analyzer	43 lbs (19.5 kg)
Weight, Pump Pack	16 lbs (7 kg)
Power, Analyzer	110 v~60 Hz, 220 v~50 Hz, 240 v~50 Hz, 250 watts
Power, Analyzer[3]	230 v~50 Hz, 2.5A
Power, Ext. Pump	110 v~60 Hz, 220 v~50 Hz, 240 v~50 Hz, 295 watts
Power, Ext. Pump[3]	230 v~50 Hz, 2.5 A
Environmental Conditions	Installation Category (Overvoltage Category) II Pollution Degree 2
Recorder Output[4]	4 - 20 mA non-isolated standard, 0-100 mV, 0-1, 5, 10 v ; resolution of 1 part in 1024 of selected voltage or current range. 4 - 20 mA isolated optional.
Status Option	12 Status Outputs from opto-isolator
Measurement Units	PPM, mg/m^3

1. Defined as twice the zero noise level.
2. At constant temperature and voltage.
3. Electrical ratings for CE Mark compliance.
4. Bi-polar. (voltage or current selectable by the jumper on the motherboard)

3.2 Warranty

WARRANTY POLICY (02024c)

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting is to be performed by the customer.

NON-TELEDYNE API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service for a period of one year from the date of delivery. All replacement parts and repairs are warranted for 90 days after the purchase.

If a Product fails to conform to its specifications within the warranty period, Teledyne API shall correct such defect by, in Teledyne API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by Teledyne API or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. TELEDYNE API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF TELEDYNE API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

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4 THE M100AH SO_2 ANALYZER

4.1 Principle of Operation

The operation of Teledyne API Model 100AH Analyzer is based upon the well proven technology from the measurement of fluorescence of SO_2 due to absorption of UV energy. Sulfur Dioxide absorbs in the 190 nm - 230 nm region free of quenching by air and relatively free of other interference.

The UV lamp emits ultraviolet radiation which passes through a 214 nm filter (allowing 214 nm light through), exciting the SO_2 molecules and producing fluorescence which is measured by a PMT with a secondary UV filter. The equations describing the above reactions are as follows:

$$SO_2 + hv_1 \xrightarrow{Ia} SO2^* \quad (1)$$

The ultraviolet light at any point in the system is given by:

$$Ia = I_0\left[1 - exp\left(-ax\left(SO_2\right)\right)\right] \quad (2)$$

Where I_0 is the UV light intensity, a is the absorption coefficient of SO_2, x the path length, and (SO_2) the concentration of SO_2. The excited SO_2 decays back to the ground state emitting a characteristic fluorescence:

$$SO_2^* \xrightarrow{KF} SO_2 + hv_2 \quad (3)$$

The block diagram in Figure 4-1 illustrates the general operation principle of the Model 100AH. Ultraviolet light is focused through a narrow 214 nm bandpass filter into the reaction chamber. Here it excites the SO_2 molecules, which give off their characteristic decay radiation. The sample is under vacuum to minimize quenching effect from CO_2 and O_2. A second filter allows only the decay radiation to fall on the PMT. The PMT transfers the light energy into the electrical signal in the sample stream being analyzed. The preamp board converts this signal into a voltage which is further conditioned by the signal processing electronics.

The UV light source is measured by a UV detector. Software calculates the ratio of the PMT output and the UV detector in order to compensate for variations in the UV light energy. Stray light is the background light produced with zero PPM SO_2. Once this background light is subtracted, the CPU will convert this electrical signal into the SO_2 concentration.

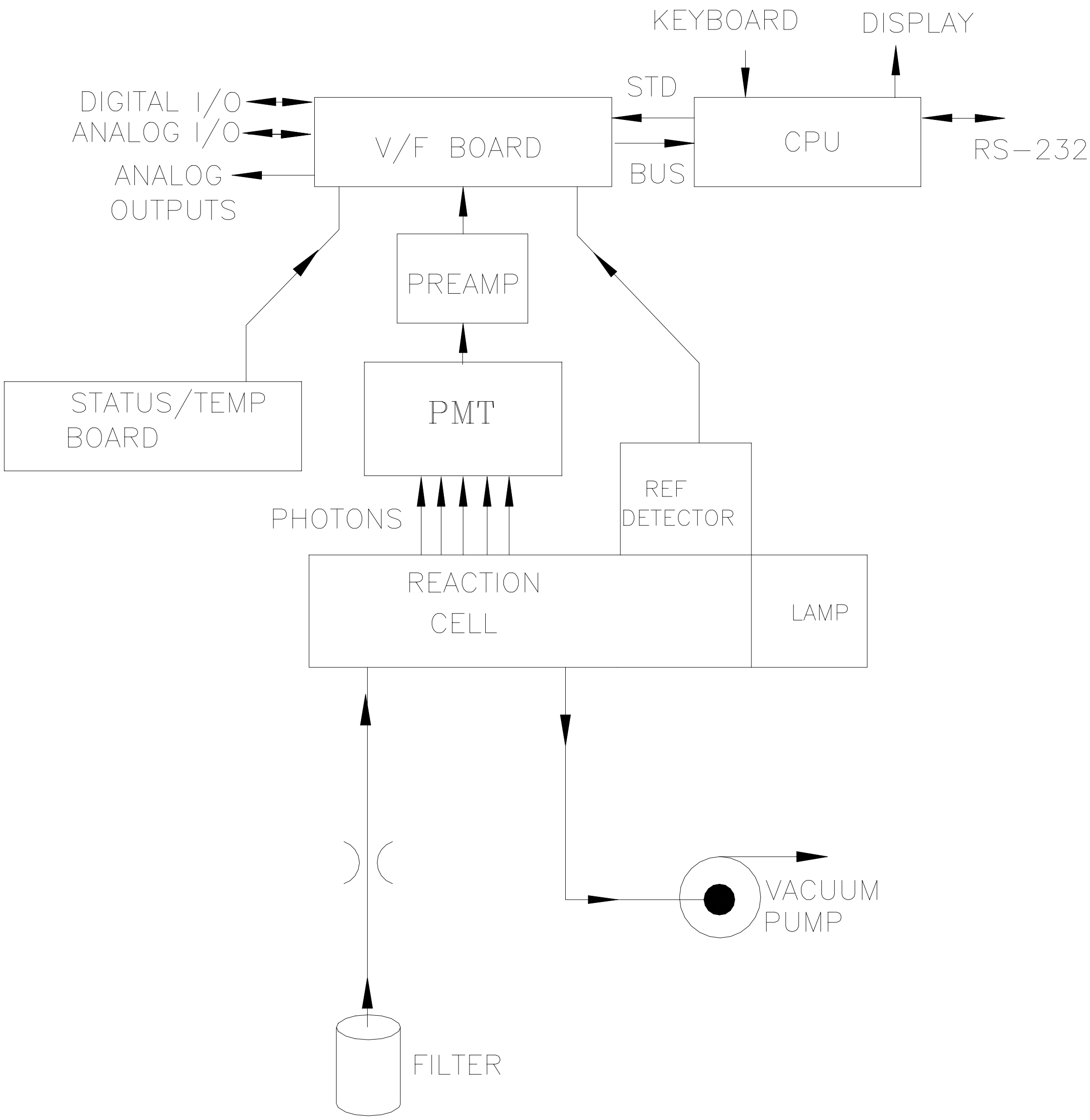


Figure 4-1: M100AH Sulfur Dioxide Analyzer

4.2 Instrument Description

4.2.1 Sensor Module, Reaction Cell, Detector

The sensor module (Figure 10-6) is where the fluorescence light is generated and detected. It is the most complicated and critical sub-assembly in the entire analyzer. It consists of the following assemblies and functions:

1. The reaction cell
2. Reaction cell heater/thermistor
3. PMT and HVPS (high voltage power supply)
4. PMT cooler/cold block/heatsink/fan
5. Preamp assembly:
   A. Preamp range control hardware
   B. HVPS control
   C. PMT cooler temp control
6. Electric and optic test electronics
7. Light trap
8. UV lamp and UV detector

4.2.2 Pneumatic Sensor Board

The pneumatic sensor board consists of two pressure sensors mounted on the flow control module. One pressure sensor measures the upstream of the flow control module which is near ambient pressure. The second pressure sensor measures reaction cell's pressure which is about one-quarter of ambient pressure. From these two pressure the sample flow rate can be computed and is displayed as sample flow in the test menu including two pressure readings. The M100AH displays pressure in inches of mercury-absolute (in-Hg-A) and flow in cc/min.

4.2.3 Computer Hardware and Software

The M100AH Analyzer is operated by a micro computer. The computer's multitasking operating system allows it to do instrument control, monitor test points, provide analog output and provide a user interface via the display, keyboard and RS-232 port. These operations appear to be happening simultaneously but are actually done sequentially based on a priority queuing system maintained by the operating system. The jobs are queued for execution only when needed, therefore the system is very efficient with computer resources.

The M100AH is a true computer based instrument. The microprocessor does most of the instrument control functions such as temperature control, and valve switching. Data collection and processing are done entirely in the CPU with the final concentration values being sent to a D/A converter to produce the instrument analog output.

The computer memory is divided into 3 sections: EPROM memory contains the multi-tasking operating system code plus the instructions that run the instrument. The RAM memory is used to hold temporary variables and current concentration data. The EEPROM memory contains the instrument set-up variables such as range and instrument ID number. The EEPROM data is non-volatile so the instrument can lose power and the current set-up information is preserved.

4.2.4 V/F Board

Computer communication is done via 2 major hardware assemblies. These are the V/F board and the front panel display/keyboard.

The V/F board is multifunctional, consisting of A/D input channels, digital I/O channels, and analog output channels. Communication with the computer is via a STD bus interface. The computer receives all of the instrument data and provides all control functions through the V/F board.

4.2.5 Front Panel

The front panel of the M100AH is shown in Figure 2-4. The front panel consists of a 2 line display and keyboard, 3 status LED's and power switch. Communication with the display, keyboard, and status LED's is done via the computer's on-board parallel port. The M100AH was designed as a computer controlled instrument, therefore all major operations can be controlled from the front panel display and keyboard.

Table 4-1: System Modes Display

Mode	Meaning
SAMPLE	Sampling normally. Flashing indicates adaptive filter is on.
SAMPLE A	Sampling normally. AutoCal enabled.
ZERO CAL A	Doing a ACAL (AutoCal) zero check or adjust
ZERO CAL M	Doing a manual zero check or adjust
ZERO CAL R	Doing a remote zero check
SPAN CAL A	Doing a ACAL (AutoCal) high span check or adjust
SPAN CAL M	Doing a manual high span check or adjust
SPAN CAL R	Doing a remote high span check
LOW CAL A	Doing a ACAL (AutoCal) low span check
LOW CAL M	Doing a manual low span check
LOW CAL R	Doing a remote low span check
M-P CAL	Doing a multi-point calibration
SETUP nnn	Configuring analyzer (sampling continues). Software revision shown.
DIAG I/O	Diagnostic test mode for Signal I/O
DIAG AOUT	Diagnostic test mode for analog output
DIAG D/A	Diagnostic test mode for DAC calibration
DIAG OPTIC	Diagnostic test mode for Optic test
DIAG Elec	Diagnostic test mode for Electrical test
DIAG RS232	Diagnostic test mode for RS-232 test
DIAG LAMP	Diagnostic test mode for Lamp calibration
DIAG TCHN	Diagnostic test mode for Test channel output

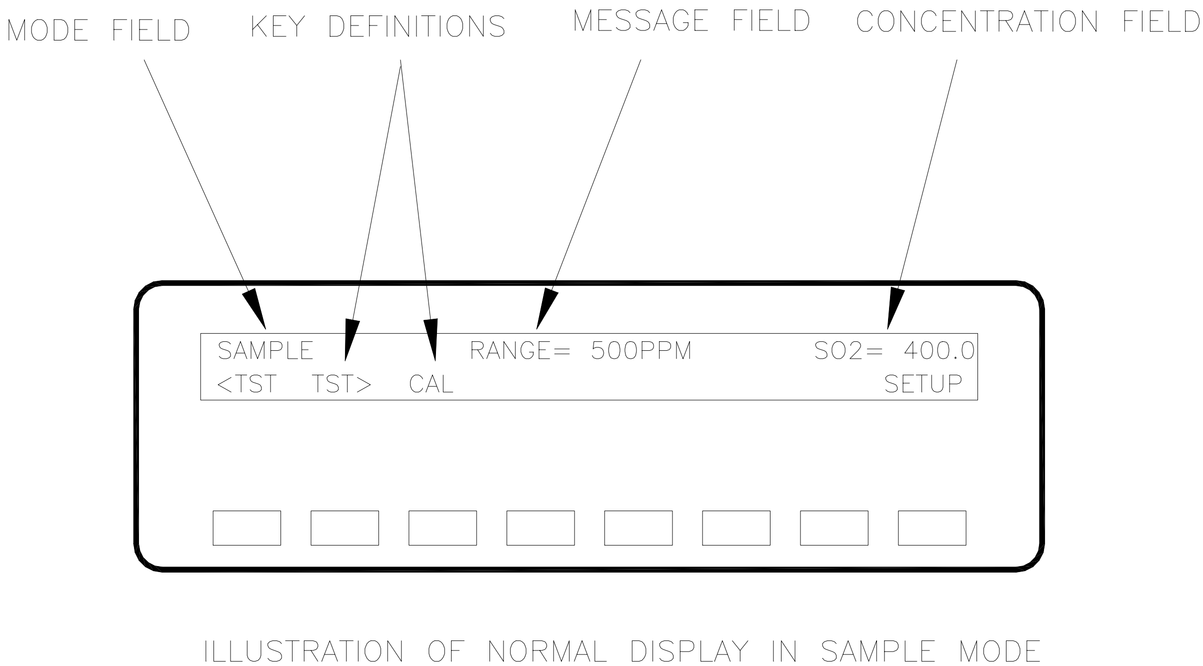


Figure 4-2: Front Panel Display

The display consists of 2 lines of 40 characters each (see Figure 4-2). The top line is divided into 3 fields, and displays information. The first field is the mode field. The mode field indicates the current mode of the Analyzer. Usually, it shows "SAMPLE", indicating that the instrument is in sample mode. The center field displays TEST values. The TEST functions allow you to quickly access many important internal operating parameters of the M100AH. This provides a quick check on the internal health of the instrument. The right hand field shows current concentration value of SO_2.

4.2.5.1 Front Panel Display

The second line of the display contains eight fields. Each field defines the key immediately below it. By redefining the keys dynamically it is possible to simplify the instrument electronics and user interface.

4.2.5.2 Status LED's

At the right of the display there are 3 status LED's. They can be in three states, OFF, ON, and Blinking. The meanings of the LED's are given in Table 4-2.

Table 4-2: Front Panel Status LED's

LED	State	Meaning
Green	Off On Blinking	NOT monitoring, DAS disabled or inactive Monitoring normally, taking DAS data Monitoring, DAS in HOLDOFF mode (1)
Yellow	Off On Blinking	Autocal disabled Autocal enabled Calibrating
Red	Off Blinking	No warnings exist Warnings exist
(1) This occurs and means during Calibration, DAS holdoff, Power-up Holdoff, and when in Diagnostic mode.		

4.2.5.3 Power Switch

The power switch has two functions. The rocker switch controls overall power to the instrument; in addition it includes a circuit breaker. If attempts to power up the M100AH result in a circuit breaker trip, the switch automatically returns to the off position, and the instrument will not power up. If this occurs, consult troubleshooting section or factory.

4.2.6 Power Supply Module

The Power supply module (PSM) supplies AC and DC power to the rest of the instrument. It consists of a 4 output linear DC power supply and a 15 volt switching supply. In addition, it contains the switching circuitry to drive the DC operated valves and several switched AC loads to operate the reaction cell and UV lamp.

4.2.7 Pneumatic System

In the basic analyzer, the sample enters through a 5-micron TFE filter element. The sample then enters the flow control module and the reaction cell. The external pump pack is supplied as standard equipment with the M100AH.

When the zero/span valve option is included, the sample passes through the valve manifold and then enters the reaction cell. (See Section 6.)

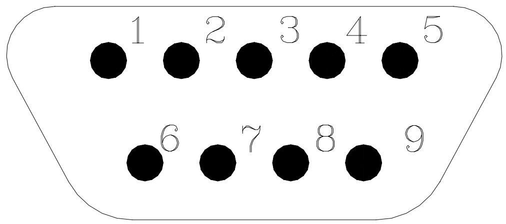
Sample flow is controlled by a critical flow orifice. The orifice is protected by a 20-micron filter. The orifice never needs adjustment. The critical flow orifice maintains precise volumetric flow control as long as the down stream pressure of the orifice is maintained under critical pressure. For example, at or near 14" (350 mm) Hg absolute at sea level.

4.3 I/O Hardware Interface

4.3.1 RS-232 Interface

The M100AH uses the RS-232 communications protocol to allow the instrument to be connected to a variety of computer based equipment. RS-232 has been used for many years and is well documented. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully.

Data Communications Software for a PC: You will need to purchase a software package so your computer can transmit and receive on its serial port. There are many such programs, we use PROCOMM at TELEDYNE API. Once you set up the variables in PROCOMM and your wiring connections are correct, you will be able to communicate with the analyzer. Make sure the analyzer is set up for 2400 baud (SETUP-MORE-COMM-BAUD) and that PROCOMM is set up as described in the "RS-232 Pin Assignments" Figure 4-3.



PIN	FUNCTION
2	TX DATA[1]
3	RX DATA[1]
5	SIG GROUND
6	DSR
7	RTS
8	CTS

RS–232 CONFIGURATION PARAMETERS

2400 BAUD DEFAULT *
8 DATA BITS
1 STOP BIT
NO PARITY

* SETTABLE 300,1200,2400
4800,9600,19200 BAUD

1 JUMPER SETTABLE ON REAR PANEL CONNECTOR BOARD

Figure 4-3: RS-232 Pin Assignments

4.3.1.1 RS-232 Connection Examples

Example 1: Connecting the M100AH (using supplied cable) to an IBM-PC AT compatible computer (DB-25 external connector, or DB-25 end of DB-9 to DB-25 Adapter).

In this case, the PC is wired as DTE and the analyzer is jumpers set as DCE, therefore a null modem is not needed. The wiring is "straight through" i.e. pin 1 to pin 1, pin 2 to pin 2, etc. Therefore all you have to do here is adapt the connector on the analyzer cable (male DB-25) to the DB-25 male on the PC. A female to female DB-25 "gender changer" (cable or adapter) will complete the connection. Make sure none of the adapters have null modems in them.

Example 2: Connecting the Teledyne API analyzer to a serial printer.

In this case, it will be necessary to determine whether the printer is DCE or DTE. Some printers can be configured for either DCE or DTE by jumpers or DIP switch settings. Consult the user manual for the printer. If the DB-25 connector pinout shows that data is output on pin 2 (from the printer), then it is DTE and the TELEDYNE API analyzer should be switch set to DCE mode. If pin 2 of the printer DB-25 is an input to the printer, then set the switch of the analyzer to DTE mode. Refer to drawing #01916.

Example 3: Connecting the Teledyne API analyzer to a modem.

The modem is always configured as DCE. Therefore, setting switch as the DTE will be required to connect the analyzer to the modem. Refer to drawing #01916.

4.3.1.2 RS-232 Diagnostic Procedures

There are several features of the M100AH to make connecting to RS-232 and diagnosing RS-232 faults easier.

There are two LED's on the rear panel Connector Board that which are connected to pin 2 and 3 of the DB-9 connector on the board. If the switch is in the DCE position (default) the red LED is connected to pin 3 of the DB-9 connector. When data is transmitted by the M100AH the red LED will flicker, indicating data present on this line. When the M100AH is running, the LED will normally be ON, indicating logic low. A one second burst of data can be transmitted over the port by a command in the DIAGNOSTIC menu. Press SETUP-DIAG, scroll to select RS232 and press ENTR to transmit a burst of lower case "w"'s.

The green LED is connected to pin 2. If the switch is in the default DCE position, this is the pin on which the M100AH receives data. It is ON if an outside device is connected. This LED gets its power from the outside device. When data is being transmitted by the outside device to the M100AH this LED will flicker.

When you are attempting to configure the RS-232 port, if either of the LED's go out when the cable is connected, that generally means that there is a grounding problem. Check the relative ground levels of pin 5 on the DB-9.

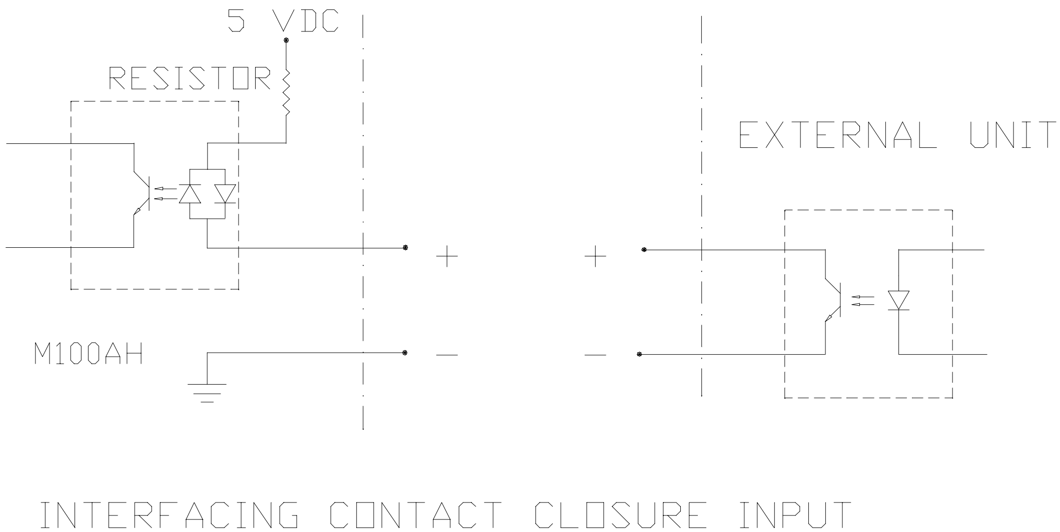
4.3.2 Status Output Interface

The status output is a feature that reports the Analyzer conditions via contact closures on the rear panel. The closures are available on a 50 pin connector on the rear panel. The contacts are NPN transistors which can draw up to 50 mA of DC current. The pin assignments are listed in the Table below.

Table 4-3: Status Output Pin Assignments

Output #	PIN #	Definition	Condition
1	1 (-), 2 (+)	ZERO CAL	CLOSED IN ZERO CAL
2	3 (-), 4 (+)	SPAN CAL	CLOSED IN SPAN CAL
3	5 (-), 6 (+)	FLOW ALARM	CLOSED IF FLOW WARNING
4	7 (-), 8 (+)	TEMP ALARM	CLOSED IF ANY TEMP WARNING
5	9 (-), 10 (+)	DIAG MODE	CLOSED IN DIAG MODE
6	11 (-), 12 (+)	POWER OK	CLOSED IF SYSTEM POWER OK
7	21 (-), 22 (+)	SYSTEM OK	CLOSED IF SYSTEM OK
8	19 (-), 20 (+)	HVPS ALARM	CLOSED IF HVPS WARNING
9	13 (-), 14 (+)	SPARE	
10	23 (-), 24 (+)	HIGH RANGE	CLOSED IF HIGH PMT RANGE
11	25 (-), 26 (+)	LOW SPAN CAL	LOW SPAN CALIBRATION
12	27 (-), 28 (+)	UV LAMP ALARM	CLOSED IF UV LAMP WARNING

The Status/Temp Board schematic can be found in the Appendix Drawing 01087.



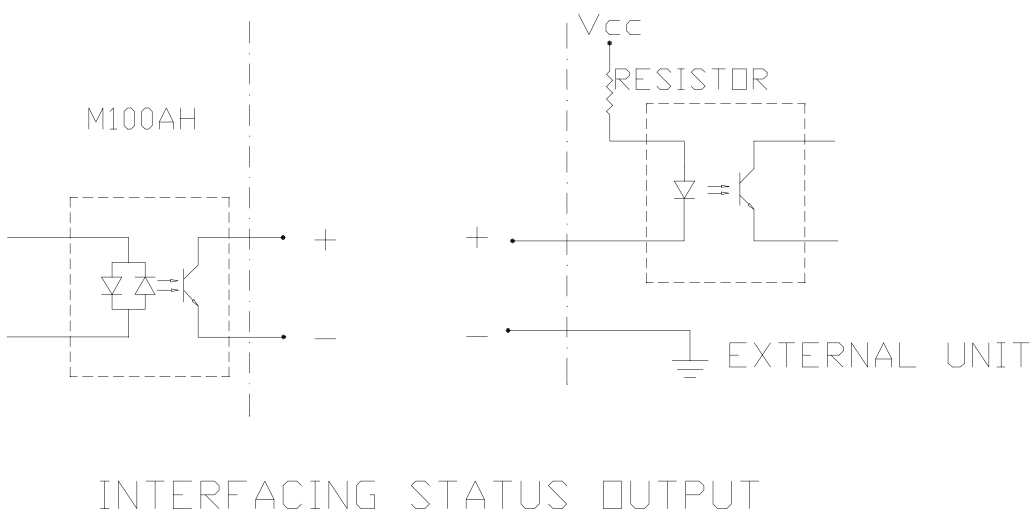


Figure 4-4: Interfacing Contact Closure I/O

4.3.3 Contact Closure Control Input Interface

The Zero/Span calibration can be initiated using external control inputs to control optional Zero/Span valves. There are 4 optoisolator type control inputs available and each input is assigned by the software for specific calibration control. Refer to Figure 2-2 REMOTE IN PIN ASSIGNMENTS Table and Figure 4-4 for interfacing with external device. Refer to Section 8.5 for additional information.

Figure 4-4 shows an example of a control input interfacing circuit. The input current through the LED is limited by a built-in resistor to prevent damage due to over-current. Once the desired input channels are properly connected, the user can set up each input to perform specific calibration. The input signal should be a high level (opto closed) with a minimum duration of 1 second.

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5 SOFTWARE FEATURES

This section covers the software features of M100AH which is designed as a computer controlled instrument. All major operations are controlled from the front panel display and keyboard through a user friendly menu. **Sample mode** is explained for the basic operation of the analyzer including calibration steps. Advanced software features are covered for experienced users under the **Setup mode** offering advanced instrument control capabilities for optimum operation of the instrument. See "Section 2 Getting Started" for installation and initial operation.

5.1 Index To Front Panel Menus

The next several pages contain two different styles of indexes that will allow you to navigate the M100AH software menus. The first two pages show a "tree" menu structure to let you see at a glance where each software feature is located in the menu. The second menu contains a brief description of each key mnemonic and a reference to the section of the manual that describes its purpose and function in detail.

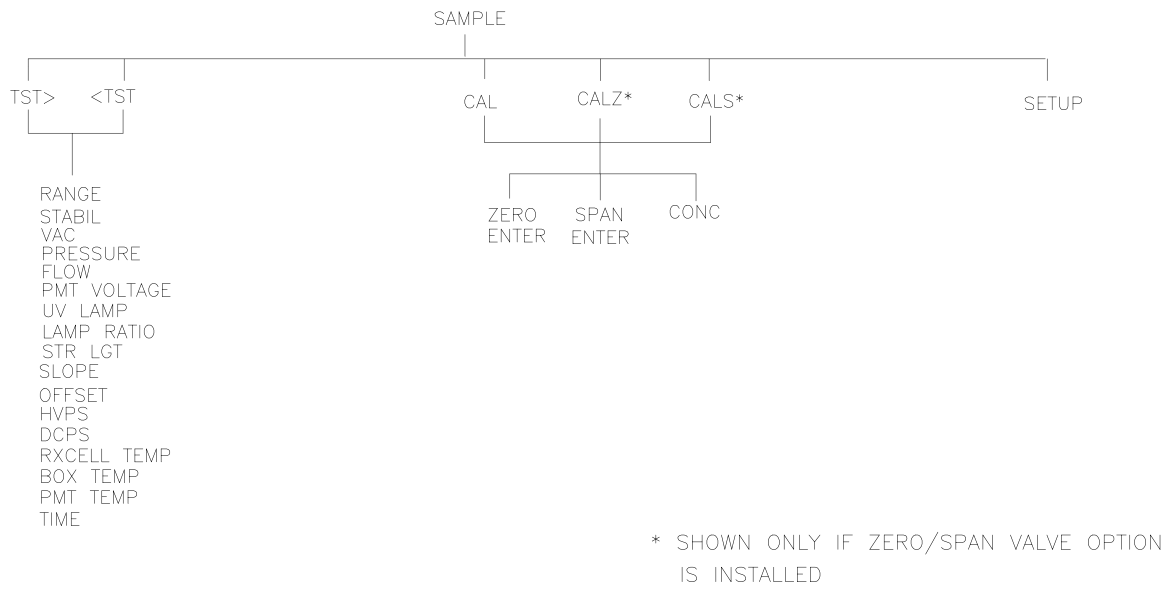

Figure 5-1: Sample Menu

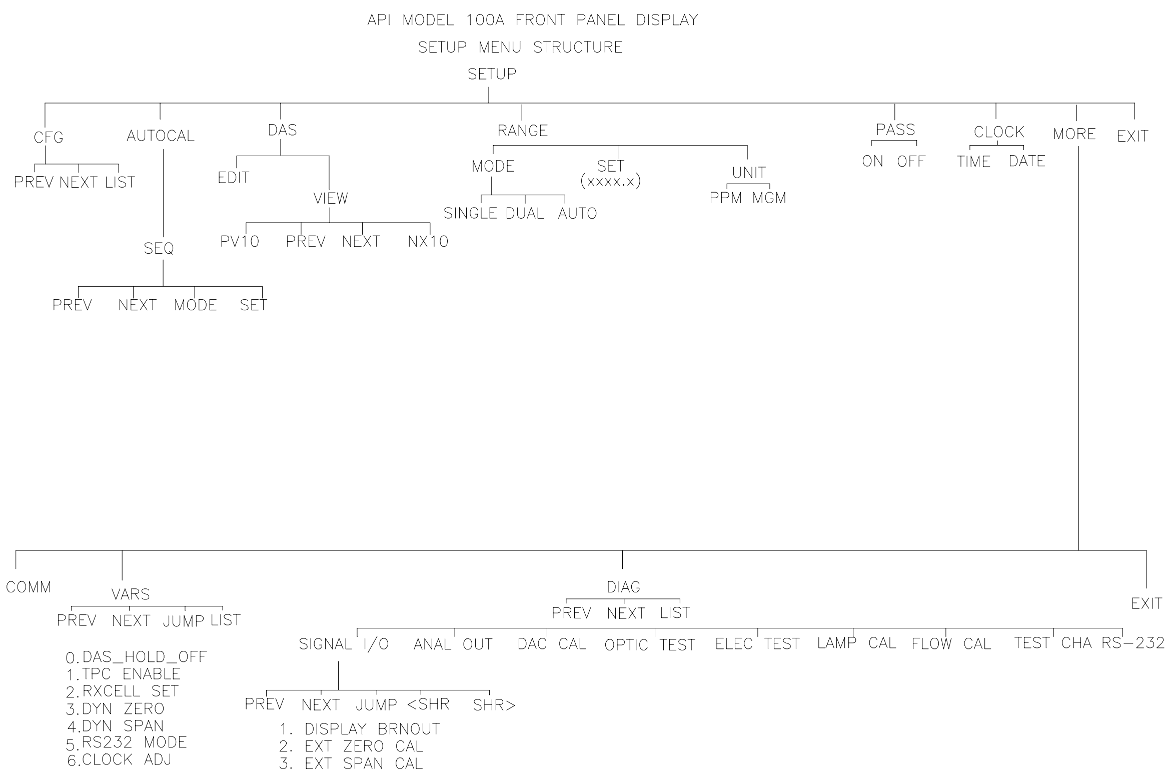

Figure 5-2: Setup Menu Tree

5.1.1 Sample Menu

Table 5-1: M100AH Sample Menu Structure

Menu Level					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
TEST TST>				Test functions	5.2.1, Table 10-1
CAL				Zero/Span calibration w/ gas through sample port	5.2.2.1, 8.1
	LOW			Shown if AUTO or DUAL range selected for low span calibration	5.2.2.3, 5.3.4
	HIGH			Shown if AUTO or DUAL range selected for high span calibration	5.2.2.3, 5.3.4
CALZ				Zero calibration w/ zero gas from zero valve option	5.2.2.2, 8.2, 8.3
CALS				Span calibration w/ span gas from span valve option	5.2.2.3, 8.2, 8.3
	ZERO			Press ZERO then ENTR will zero analyzer	5.2.2.2
	SPAN			Press SPAN then ENTR will span analyzer	5.2.2.3
		LOW		Low span gas calibration	5.2.2.3
		HIGH		High span gas calibration	5.2.2.3
	CONC			Expected SO_2 span concentration	5.2.2.4
SETUP				The SETUP Menu - See next table	Table 5-2

5.1.2 Set-Up Menu

Table 5-2: M100AH Setup Menu Structure

Setup Menu #1					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
CFG				CFG is primarily used for showing special configuration options and factory special software	5.3.1
	PREV, NEXT, LIST			PREV, NEXT can be used to scroll through the configuration list LIST automatically scrolls the list	5.3.1
AUTOCAL				Automatic zero/span check or calibration	5.3.2, 6.3
	SEQ_x			Select SEQUENCE 1 thru 3	5.3.2, 6.3
		MODE		Disable or enable zero and/or span mode	5.3.2, 6.3
		SET		SETUP automatic zero/sapn calibration sequence	5.3.2, 6.3
DAS				Data Acquisition System (DAS) -	5.3.3
	EDIT			SETUP Data Acquisition System (DAS)	5.3.3
	VIEW	PREV		Examine the DAS data buffer - display previous average	5.3.3
		PV10		Move UP previous 10 averages in the DAS data buffer	5.3.3
		NEXT		Examine the DAS data buffer - display next average	5.3.3
		NX10		Display next 10 averages in the DAS data buffer	5.3.3

Table 5-3: M100AH Menu Structure - Setup Menu #2

Setup Menu #2					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
RNGE				Range control menu	5.3.4
	MODE			Range mode select - Single, Autorange, Dual	5.3.4
		AUTO		Automatically select output range	5.3.4
		DUAL		Independent output ranges for REC and DAS	5.3.4
		SINGLE		Single range for both REC and DAS outputs	5.3.4
	SET			Sets range if mode is Single range	5.3.4.1
		LO		Sets low range value if Autorange enabled	5.3.4.2
		HI		Sets high range value if Autorange enabled	5.3.4.2
	UNITS			Unit selection menu	5.3.4.4
		PPM, MGM		Select units that instrument uses	5.3.4.4
PASS				Password enable/disable menu	5.3.5
	ON-OFF			Enable/disable password checking	5.3.5
CLOCK	TIME			Adjusts time on the internal time of day clock	5.3.6
	DATE			Adjusts date on the internal time of day clock	5.3.6
MORE				Continue menu one MORE level down	Table 5-4

Table 5-4: M100AH Menu Structure - Setup Menu #3

Setup Menu #3					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
MORE				Next level of the SETUP menu	
	COMM			RS-232 communications control menu	5.3.8
		BAUD	300-1200-2400-4800-9600-19.2k	Set the BAUD rate to 300-1200-2400-4800-9600-19.2K	5.3.8, 7.1
		ID		Sets the instrument ID-(included on all RS-232 messages)	5.3.8, 7.1.1
	VARS			Internal variables	5.3.9, 10.1.4
		PREV, NEXT, JUMP, EDIT		PREV, NEXT scroll up and down through the VARS menu. Jump will go to variable number selected, EDIT will allow editing of the selected variable.	5.3.9, 10.1.4
	DIAG			Diagnostic menu	5.3.7, 10.1.3
		PREV, NEXT		PREV, NEXT scroll up and down through the DIAG menu. (SIGNAL I/O, ANALOG OUTPUT, D/A CALIBRATION, OPTIC TEST, ELECTRICAL TEST, LAMP CALIBRATION, TEST CHAN OUTPUT, RS-232 OUTPUT)	5.3.7, 10.1.3

5.2 Sample Mode

5.2.1 Test Functions

NOTE

In any of the following TEST functions, if XXXX is displayed, that indicates an off scale and therefore meaningless reading.

To use the TEST functions to diagnose instrument faults, refer to Troubleshooting Section 10.1.

Range

This is the range of the instrument. In standard configuration there is one range for both REC and DAS outputs.

Dual range allows a different range for each output. When enabled, the RANGE test measurement is replaced with two different test measurements, RANGE1 (LOW RANGE) and RANGE2 (HIGH RANGE).

Auto range option allows a low range and high range. The M100AH will automatically switch to the other range dynamically as concentration values require. The TEST values will show the range the instrument is currently operating in, and will dynamically display the alternate range as the range changes occur.

Stability

The instrument stability is used to indicate the stability of measurement of analyzer. It is computed as the standard deviation of 25 samples of a moving window with interval of 10 seconds between each sample.

Sample Pressure

Sample pressure is measured using a solid state pressure sensor at the upstream of the flow control module. This reading will vary according to the sample gas pressure, altitude and local weather condition.

Vacuum Pressure

Sample pressure is measured at the downstream of the flow control module. This reading is the reaction cell pressure which is used by the CPU to compensate the SO_2 concentration due to its pressure of the sample gas in the reaction cell.

Sample Flow

The sample flow is computed from the pressure measured upstream of the flow control module. Since the downstream of the orifice is well within the critical pressure (which is also checked continuously), it is the upstream pressure of the orifice responsible directly proportional to the flow through the orifice. Flow variation has little effect on the analyzer reading. Its nominal value is 650 ± 60 cc/min.

PMT Voltage

The PMT VOLTAGE measures the PMT signal at the output of the preamp board. The waveform of the PMT voltage can be complex, and vary up to 5000 mV when a high concentration of SO_2 is being measured. If the PMT reading is consistently 5000 mV, that indicates an off-scale reading. Typical readings bounce around, which is normal.

UV Lamp

UV Lamp reading is the measurement voltage from the reference detector preamp board. Typical value is between 2000 mV and 4000 mV and above 600 mV is acceptable.

Stray Light

Stray Light is the background light of the reaction cell expressed in PPM while sampling zero gas. It is only an indication of the condition of the optical system such as lenses, UV filter, light leak, etc.

Dark PMT

The dark current of the PMT is periodically measured to compensate any PMT dark current drift and offset. Typical value is less than 200 mV.

Dark Lamp

This is the dark current of the UV reference detector which is used to compensate any dark current drift and offset. This measurement is synchronized to the Dark PMT measurement period. Typical value is less than 200 mV.

Slope

The coefficient of straight line equation ($y = mx + b$) determines the calibration of the M100AH. The slope parameter (m) can be thought of as a gain term which determines the steepness of the calibration curve. Typical value is 1 ± 0.3.

Offset

The offset parameter (b) compensates for differences in the background signal of the optical system. Typical value is less than 100 mV.

High Voltage Power Supply (HVPS)

The HVPS reading is a measure of the scaled-up HVPS programming voltage. The voltage used to set the HVPS output is generated on the Preamp board. Its value is between 0 and 1 volt, corresponding to a voltage of 0 to 1000 volts out of the HVPS. The HVPS front panel TEST measurement will be typically around 450-650 V.

DC Power Supply (DCPS)

The DCPS voltage is a composite of the 5 and ± 15 VDC voltages in the Power Supply Module. This is meant to be a quick indicator to show if the PSM is working correctly. The nominal value is 2500 mV ± 200 mV.

Reaction Cell Temperature

This is a measurement of the temperature of the reaction cell. It is controlled by the computer to 50 ± 1°C. Temperatures outside this range will cause the M100AH output to drift.

Box Temperature

This TEST function measures the temperature inside the chassis of the M100AH. The temperature sensor is located on the Status/Temp Board. Typically it runs 2 to 10°C higher than the ambient temperature. The M100AH has been engineered to operate over 5 to 40°C ambient temperature range.

PMT Temperature

The temperature of the PMT is closely controlled by a dedicated proportional temperature controller. The nominal set-point is 7 ± 1°C. Readings outside this range will cause instrument drift due to gain changes in the PMT detector.

Time

This is an output of the M100AH's internal time of day clock.

5.2.2 CAL, CALS, CALZ, Calibration Functions

The calibration and zero/span checking of the M100AH analyzer is treated in detail in Section 8. Table 8-1 summarizes types of calibration.

5.2.2.1 CAL, CALS, CALZ

The CAL, CALS, and CALZ keys control the calibration functions of the analyzer. In the CAL mode the analyzer can be calibrated with zero/span gas coming in through the sample filter assembly on the rear panel. If the instrument will be used on more than one range such as AUTO RANGE or DUAL RANGE, it should be calibrated separately on each applicable range (see Section 5.3.4 and 8.1 for calibration procedure).

If the analyzer is equipped with the optional Zero/Span valves, there will also be CALZ and CALS buttons. The setup of this option is covered in Section 6.3, and operation is explained in Section 8.2.

5.2.2.2 Zero

Pressing the ZERO key along with ENTR will cause the instrument to adjust the OFFSET value of the internal formula so that the instrument reads zero. The M100AH allows zero adjustment over a limited range of signal levels mostly due to the background signal, therefore the signal does not have to be exactly zero for the instrument to do a zero cal. The instrument will not, however, allow a zero cal on any signal level, therefore it is not possible to zero the instrument with span gas in the reaction cell. If the ZERO key does not come on as expected, check Section 10.2.9.

5.2.2.3 Span

Pressing the SPAN key along with ENTR will cause the instrument to adjust the SLOPE value of the internal formula so the instrument displays the span value. The expected SO_2 span concentration must be entered before doing a SPAN calibration. See Table 8-3.

Like the Zero calibration, the Span cal cannot be done with any concentration of span gas. If the signal level is outside certain limits, the SPAN key will not be illuminated. If you encounter this condition see Section 10.2.8. It is also possible at low levels of span concentration that both the ZERO and SPAN keys might be on, thus allowing you to either zero or span the instrument. In this case, care must be taken to perform the correct operation or the analyzer can become mis-calibrated.

5.2.2.4 SO_2 Cal Concentration

Before the M100AH can be spanned, it is necessary to enter the expected span concentrations for SO_2. This is done by using CAL-CONC. ***Concentration values from 10 to 4500 PPM are accepted.*** If a value of XXXX is displayed, that indicates an offscale, or invalid reading. The XXXX value will often be displayed at power-up when there is no data yet available to be displayed. Certain instrument fault conditions will cause X's to be displayed. This is the same as the needle being offscale on a analog meter. See the Troubleshooting Section 10.2.8 if this occurs.

5.2.2.5 Formula Values

The slope and offset terms should be checked after each calibration. The values for these terms contain important information about the internal health of the analyzer.

To compute the SO_2 concentration, the formula for a straight line is used.

$y = mx + b$

Where:

y = the SO_2 concentration

m = the slope

x = the conditioned PMT tube output

b = the offset

In comparison with analog analyzers the slope term is equivalent to the "span pot" and the b term is equivalent to the "zero pot". Again, like an analog analyzer, there is only a limited range of adjustment allowed for either term, and there are consequences of having the values near the high or low limits of their respective ranges.

The x term is the conditioned PMT signal. PMT signal is adjusted for the lamp ratio background, range, temperature, and pressure.

The offset (b) term is the total background light with the zero term subtracted out. The zero term measures detector dark current and amplifier noise. The b term is composed mostly of the optical system background.

5.3 Set-Up Mode

5.3.1 Configuration Information (CFG)

This menu item will tell if the installed software has factory special features or other non-standard features. If you call Teledyne API service, you may be asked for information from this menu.

5.3.2 Automatic Calibration (AutoCal)

The AutoCal feature allows the M100AH to automatically operate the Zero/Span Valve option ON on a timed basis to check or adjust its calibration. This menu item is shown only if the Zero/Span Valve option is installed. Detailed information on setting up AutoCal is found in the Section 6.3.

5.3.3 Data Acquisition System (DAS)

The Model 100AH contains a flexible and powerful built in data acquisition system (DAS) that enables the analyzer to store concentration data as well as many diagnostic parameters in its battery backed memory. This information can be viewed from the front panel or printed out through the RS-232 port. The diagnostic data can be used for performing “Predictive Diagnostics” and trending to determine when maintenance and servicing will be required.

The logged parameters are stored in what are called “Data Channels.” Each Data Channel can store multiple data parameters. The Data Channels can be programmed and customized from the front panel. A set of default Data Channels has been included in the Model 100AH software. These are described Section 5.3.3.1. For more information on programming custom Data Channels, a supplementary document containing this information can be requested from Teledyne API.

5.3.3.1 Data Channels

The function of the Data Channels is to store, report, and view data from the analyzer. The data may consist of SO_2 concentration, or may be diagnostic data, such as the sample flow or PMT output.

The M100AH comes pre-programmed with a set of useful Data Channels for logging SO_2 concentration and predictive diagnostic data. The default Data Channels can be used as they are, or they can be changed by the user to fit a specific application. They can also be deleted to make room for custom user-programmed Data Channels.

The data in the default Data Channels can be viewed through the **SETUP-DAS-VIEW** menu. Use the **PREV** and **NEXT** buttons to scroll through the Data Channels and press **VIEW** to view the data. The last record in the Data Channel is shown. Pressing **PREV** and **NEXT** will scroll through the records one at a time. Pressing **NX10** and **PV10** will move forward or backward 10 records. For Data Channels that log more than one parameter, such as PNUMTC, buttons labeled **<PRM** and **PRM>** will appear. These buttons are used to scroll through the parameters located in each record.

The function of each of the default Data Channels is described below:

CONC: Samples SO_2 concentration at one minute intervals and stores an average every hour with a time and date stamp. Readings during calibration and calibration hold off are not included in the data. The last 800 hourly averages are stored.

PNUMTC: Collects sample flow and sample pressure data at five minute intervals and stores an average once a day with a time and date stamp. This data is useful for monitoring the condition of the pump and critical flow orifice (sample flow) and the sample filter (clogging indicated by a drop in sample pressure) over time to predict when maintenance will be required. The last 360 daily averages (about 1 year) are stored.

CALDAT: Logs new slope and offset every time a zero or span calibration is performed. This Data Channel also records the instrument reading just prior to performing a calibration.

NOTE: This Data Channel collects data based on an event (a calibration) rather than a timer. This Data Channel will store data from the last 200 calibrations. This does not represent any specific length of time since it is dependent on how often calibrations are performed. As with all Data Channels, a time and date stamp is recorded for every data point logged.

5.3.3.2 RS-232 Reporting

Automatic RS-232 reporting can be independently enabled and disabled for each Data Channel. For all default data channels, RS-232 reporting is initially set to "OFF." If this property is turned on, the Data Channel will issue a report with a time and date stamp to the RS-232 port every time a data point is logged. The report format is shown below:

```
D   31:10:06  0412  CONC  : AVG  CONC1=6.8 PPM
```

The report consists of the letter "D" follow by a time/date stamp ("31:10:06") followed by the instrument ID number ("0412"). Next is the Data Channel name ("CONC") and the sampling mode ("AVG" indicates that the data point is an average of more than one sample as opposed to a instantaneous reading, "INST"). Finally, the name of the parameter and its value ("CONC1=6.8 PPM") are printed. For Data Channels that sample more than one parameter, such as PNUMTC and CALDAT, each parameter is printed on a separate line.

To enable RS-232 reporting for a specific Data Channel:

Step	Action	Comment
1.	Press **SETUP-DAS-EDIT-ENTR**	Enter DAS menu to edit Data Channels
2.	Press **PREV/NEXT**	Select Data Channel to edit
3.	Press **EDIT**	Edit selected Data Channel
4.	Press **SET>** (5 times)	Scroll through setup properties until RS-232 REPORT: OFF is displayed
5.	Press **EDIT**	Edit selected setup property
6.	Toggle **OFF** to **ON**	Change RS-232 REPORT property
7.	Press **ENTR**	Accepts change
8.	Press **EXIT** (4 times)	Exits back to sample menu

See Section 7.7 for more information on DAS reporting through the RS-232 interface.

5.3.4 Range Menu

The instrument operates on any full scale range from 10 to 5000 PPM. The range is the concentration value that equals the maximum current (or voltage) output on the rear panel of the instrument.

If the range you select is between 10 and 500 PPM the front panel display will read the concentration anywhere from 0 to 500 PPM regardless of the range selected, however the analog output is scaled for the range selected. If the range selected is from 501 to 5000 PPM the front panel display will read from 0 to 5,000 PPM. The M100AH has 2 internal hardware gain settings, namely 0-500 PPM (gain of 10) and 0-5000 PPM (gain of 1). If the physical gain changes, then the test measurement readings such as PMT and OFFSET will be adjusted accordingly.

NOTE

If the instrument will be used on more than one range such as AUTO RANGE or DUAL RANGE, it should be calibrated separately on each applicable range (see Section 8.6 for calibration procedure).

Each 4-20 mA current output channel should be connected to one interfacing device only.

There are 3 range choices: only one of the following range choices can be active at any one time.

1. **Single Range**; two analog outputs are fixed to a single range.
2. **Auto Range**; both analog outputs are automatically set for low or high range.
3. **Dual Ranges**; each of an analog output ranges can be set differently.

5.3.4.1 Single Range

This range option selects a single range for both output channels (REC, DAS) of the M100AH. To select Single Range press SETUP-RNGE-MODE-SING, then press ENTR. To set the value for the range press SETUP-RNGE-SET, and enter the full scale range desired from 10 PPM to 5000 PPM, then press ENTR.

5.3.4.2 Auto Range

Auto Range allows output range to automatically range between a low value (RANGE1) and a higher value (RANGE2). When the instrument output increases to 98% of the low range value, it will Auto Range into Hi range. In Hi range, when the output decreases to 75% of low range, it will change to the lower range. There is only one low range and one high range for all outputs. The Hi range mode is signaled by a bit on the STATUS option, see Table 4-3. If you select a Hi range that is less than Low range, the M100AH will remain locked in Low range and behave as a Single Range instrument.

To set up Auto Range press SETUP-RNGE-MODE-AUTO, then press ENTR. To set the values press SETUP-RNGE-SET. The M100AH will prompt you for Low Range, then Hi Range which is the lower and upper ranges of Auto Range. Key in the values desired, then press ENTR.

Once desired range is selected, then M100AH should be calibrated for each range entered. (Refer Section 8.6 for Calibration Procedure.)

5.3.4.3 Dual Ranges

Dual Ranges allows you to select different ranges for REC and DAS analog output channels. To set up Dual Ranges press SETUP-RNGE-MODE-DUAL, then press ENTR. To set the values press SETUP-RNGE-SET. The M100AH will prompt you for the range of RANGE1 (REC) and RANGE2 (DAS) outputs (refer to Figure 2-2 for corresponding analog output terminals). Key in the desired range for each output channel, then press ENTR after each value.

If Dual Range is selected and their desired ranges are entered accordingly, the M100AH should be calibrated for each of the range selected. See Section 8.6 for Calibration Procedure.

If user has selected either Auto Range or Dual Range, then pressing CAL button will cause to display LOW RANGE (RANGE 1) and HI RANGE (RANGE 2). Select desired range number and press ENTR to continue calibration procedure of selected range. Under each range calibration procedure, the M100AH will display separate test measurement functions accordingly to show the Slope, Offset, Range, etc. However once exit this calibration menu and return to the main menu (see Figure 2-4), then the test measurement parameters for LOW RANGE (RANGE1) are used throughout the M100AH.

5.3.4.4 Concentration Units

The M100AH can display concentrations in PPM, mg/m^3. Coefficients for mg/m^3 were based on 0°C (25°C for U.S.EPA), 760 mmHg. Different pressure and temperature can be used by adjusting values entered for calibration gas to read the correct concentration at the conditions being used. This adjustment is not needed if units are within the same type.

To change the current units press SETUP-RNGE-UNIT from the SAMPLE mode and select the desired units.

CAUTION

If the current units are in PPM and the span value is 400 PPM, and the units are change to mg/m^3 the span value is NOT re-calculated to the equivalent value in mg/m^3. Therefore the span value now becomes 400 mg/m^3 instead of 400 PPM. Use the following equation to convert the unit with proper temperature and pressure adjustments. Then recalibrate the analyzer.

$$SO_2 \ in \ ppm \times 2.86 \times \frac{T}{273^o K} \times \frac{760\, mmHg}{P} = SO_2 \ in \ {}^{mg}\!/_{m^3}$$

NOTE

You should now re-enter the expected span concentration value in different units which should be adjusted for proper pressure and temperature (25°C for U.S. EPA) in the new units and re-calibrate the instrument using one of the methods in Section 8.

Changing units affects all of the RS-232 values, all of the display values, and all of the calibration values and therefore you must re-calibrate the Analyzer.

5.3.5 Password Enable

There are two levels of password protection. The most restrictive level requires a password to do instrument calibration. The second level requires a password to do SETUP functions.

If both password levels are turned off, no passwords are required, except in the VARS menu where a password is always required. To enable password press SETUP-PASS-ON. A list of passwords is in Table 5-5.

Table 5-5: Calibrate, Setup Passwords

Password Usage		Password
Calibration Password	Use to get into CAL menus	512
Setup Password	Use to get into SETUP menus	818

5.3.6 Time of Day Clock

The instrument has an internal time of day clock. The time of day can be set by pressing SETUP-CLOCK-TIME and entering the time in 24hr format. In a similar manner the date can be entered by pressing SETUP-CLOCK-DATE and entering the date in a DD-MM-YY format. If you are having trouble with the clock running slow or fast, the speed of the clock can be adjusted by selecting the CLOCK_ADJ variable in the SETUP-MORE-VARS menu (See Section 10.1.4).

5.3.7 Diagnostic Mode

The M100AH Diagnostic Mode allows additional tests and calibrations of the instrument. These features are separate from the TEST functions because each DIAG function has the ability to alter or disable the output of the instrument. While in DIAG mode no data is placed in the DAS averages. Details on the use of Diagnostic mode are in Section 10.1.3.

5.3.8 Communications Menu

The COMM menu allows the RS-232 BAUD rate to be set. To set the BAUD rate press SETUP-MORE-COMM-BAUD, select the appropriate BAUD rate, then press ENTR.

The instrument ID number can also be set. This ID number is attached to every RS-232 message sent by the M100AH. To set the ID press SETUP-MORE-COMM-ID and enter a 4 digit number from 0000-9999, then press ENTR.

5.3.9 Variables Menu (VARS)

This menu enables you to change the settings on certain internal variables. The VARS Table 10-5 is located in the Troubleshooting Section 10.1.4.

CAUTION

Before changing the settings on any variables, make sure you understand the consequences of the change. The variables should only be changed by skilled maintenance people since they can potentially interfere with the performance of the Analyzer.

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6 OPTIONAL HARDWARE AND SOFTWARE

Optional equipment offered with the M100AH includes:

1. Rack mount with slides (P/N 00280)
2. Rack mount without slides, ears only (P/N 01470)
3. Zero/Span valves assembly (P/N 0178603)
4. 4-20mA, isolated outputs (P/N 01471)

6.1 Rack Mount Options

The Rack Mount option including slides and ears, permits the Analyzer to be mounted in a standard 19" wide x 24" deep RETMA rack. The Rack Mount option can also be ordered without slides for applications requiring the instrument to be rigidly mounted in a RETMA rack.

6.2 Zero/Span Valves

The Zero/Span Valve option consists of a manifold with four valves. See Figure 2-5 for valve location. Connections are provided on the rear panel for two (low and high) span gas and zero gas inputs to the valves (See Figure 2-2). These valves can be actuated by several methods shown in Table 6-1.

Table 6-1: Zero/Span Valve Operation

Mode	Description	Reference Section
1.	Front panel operation via CALS and CALZ buttons.	Calibration Section 8 - Manual Zero/Span Check.
2.	Automatic operation using AUTOCAL	Setup and use of AUTOCAL is described in Table 6-2, and Section 8.3.
3.	Remote operation using the RS-232 interface	Setup described in Table 7-1. Operation of AUTOCAL described in Section 6.3 and Section 7.5.
4.	Remote operation using external contact closures	Section 8.5 - Automatic operation using external contact closures. Table 8-7.

Zero/Span valves have 4 operational states:

1. Sample mode. All four valves are not energized and sample gas passes through the sample valve and into the analyzer for analysis. For any other mode, sample valve is energized to shut off sample port. Refer to Figure 9-3 Pneumatic Diagram.
2. Zero mode. The zero valve is energized allowing zero gas to be admitted into the analyzer through the rear panel bulkhead fitting.
3. Low Span mode. The low span valve is energized and low span gas is admitted into the analyzer through a rear panel bulkhead fitting.
4. High Span mode. The high span valve is energized and high span gas is admitted into the analyzer through a rear panel bulkhead fitting.

Zero air and span gas inlets should supply their respective gases in excess of the 700 cc/min (i.e. 1000 cc/min) demand of the analyzer at ambient pressure. Ideally the calibration gas pressure should be the same one as the sample gas pressure and should not differ more than 2 in-Hg. Supply and vent lines should be of sufficient length and diameter to prevent back diffusion and pressure effects. See Figure 2-3 for fitting location and tubing recommendations.

Adequate inexpensive zero air can be supplied from the room air by connecting a charcoal scrubber and 5 micron particulate filter (Teledyne API P/N 000369) to the zero air inlet tubing. The zero air scrubber used in conjunction with the Zero/Span Valve option provides an inexpensive source of zero air.

6.3 Autocal - Setup Zero/Span Valves

The Zero/Span valves system can be set up to operate automatically on a timed basis. The Teledyne API model 100AH with Zero/Span valves option offers capability to check any combination of zero and up to two span points either automatically on a timed basis, through remote RS-232 operation (see Section 7.5), or external contact closure (see Section 8.5).

There are three auto-calibration sequences called SEQ1, SEQ2, and SEQ3. Each SEQ can be programmed to perform a specific calibration sequence. Under each SEQ, there are five parameters that affect zero/span checking: the mode enable/selection, the starting date and time of the calibration, the number of delay days and time, duration of calibration, and calibration adjust enable/disable.

1. Calibration Sequence Mode

Each sequence can generate any one of 7 different combinations of ZERO, LO, or HI span point. Press SETUP-ACAL, and scroll up or down to select the desired sequence number (SEQx). Press MODE and scroll up or down by pressing PREV or NEXT. Select one of the combination shown below and press ENTR.

Combinations:

1) DISABLED; will disable corresponding SEQx setup.
2) ZERO
3) ZERO-LO
4) ZERO-HI
5) ZERO-LO-HI
6) LO
7) HI
8) LO-HI

2. Setup Calibration Timer:

Press SETUP-ACAL-SET to setup or edit the automatic calibration timer.

Following table summarizes the setup procedures:

Table 6-2: Setup Automatic Zero/Span Calibration

	Default	Description
Timer Enable	ON	Enable or disable automatic calibration timer.
Starting Date	01-JAN-95	MM:DD:YY
Starting Time	00:00	HH:MM, 0 - 23 hours and 0 - 59 minutes
Delta Days	1	Delay days between each calibration (0 - 365 days)
Delta Time	00:00	HH:MM, 0 - 23 hours and 0 - 59 minutes
Duration	15.0 minutes	1 - 60.0 minutes
Calibrate	OFF	on/off. If ON is selected, it will adjust the calibration.

The Timer Enable can be set to “OFF” to disable the automatic calibration timer while the remote RS-232 calibration of specific sequence can be initiated.

NOTE

Avoid setting two or more sequences at the same time of the day. Any new sequence which is initiated whether from a timer, the RS-232, or the contact closure inputs will override any sequence that is in progress.

The programmed start time must be a minimum of 5 minutes later than the real time clock.

Examples of possible sequences are as following under any one of three available SEQx.

Example 1: To perform zero-span calibration check once per day at 10:30 PM, 5/20/97.

1) MODE: ZERO-HI
2) TIMER ENABLE: ON
3) STARTING DATE: 5/20/97
4) STARTING TIME: 22:30
5) DELTA DAYS: 1
6) DELTA TIME: 00:00
7) DURATION: 15.0 MINUTES
8) CALIBRATE: OFF

Example 2: To perform zero calibration adjust once per day retarding 15 minutes everyday starting at 11:30 pm, 5/20/97.

1) MODE: ZERO
2) TIMER ENABLE: ON
3) STARTING DATE: 5/20/97
4) STARTING TIME: 23:30
5) DELTA DAYS: 0
6) DELTA TIME: 23:45
7) DURATION: 15.0 MINUTES
8) CALIBRATE: ON

Example 3: To perform zero-span calibration check once per day at 10:30 PM and zero calibration adjust once per week starting at 11:30 PM, 5/20/97.

1. Select any one of SEQx and setup as example 1 above.
2. Select any other SEQx and program as follows. Always avoid setting two or more sequences at the same time of the day.
   1) MODE: ZERO
   2) TIMER ENABLE: ON
   3) STARTING DATE: 5/20/97
   4) STARTING TIME: 23:30
   5) DELTA DAYS: 7
   6) DELTA TIME: 00:00
   7) DURATION: 15.0 MINUTES
   8) CALIBRATE: ON

6.4 4-20 mA, Isolated Current Loop Output

The standard non-isolated 4-20 mA current output provides current output capability by sharing the common electrical ground. The optional current output offers to isolate the electrical ground from the external ground of the interfacing device. The setup and operation is identical to the non-isolated current output. See Troubleshooting Section 10 for electrical calibration procedure and refer to drawings 01087 and 01248 for the jumper settings. Depending on the jumper setting, it can be used for the current output or the voltage output.

NOTE

Each 4-20 mA current output should be connected to one interfacing device only.

7 RS-232 INTERFACE

The RS-232 communications protocol allows the instrument to be connected to a wide variety of computer based equipment. The interface provides two basic functions in the M100AH.

1. First is a comprehensive command interface for operating and diagnosing the analyzer. This interface has in fact more capabilities than the front panel keyboard.
2. The interface can provide an audit trail of analyzer events. In this function the port sends out messages about instrument events like calibration or warning messages. If these messages are captured on a printer or remote computer, they provide a continuous audit trail of the analyzers operation and status.

7.1 Setting Up the RS-232 Interface

The baud rate is set from the front panel by SETUP-MORE-COMM-BAUD. Select the baud rate appropriate for your application, 300, 1200, 2400, 4800, 9600, 19.2K. **It is important to note that the interfacing device must have identical settings in order for the communications to work correctly.**

Second is physical wiring of the analyzer to the other unit. We have incorporated into the analyzer LED's that signal the presence of data on the communications lines, and also jumper blocks to easily re-configure the analyzer from DCE to DTE if necessary (see drawing #01917). In addition the front panel diagnostics allow test data streams to be sent out of the port on command. This flexibility and diagnostic capability should simplify attaching our equipment to other computers or printers. If problems occur, see the Section 4.3.1.2.

7.1.1 Setup from the Front Panel

There are 2 additional RS-232 setups that can be done via the front panel.

1. Set the Instrument ID number by SETUP-MORE-COMM-ID, and enter a 4 digit number from 0000-9999. This ID number is part of every message transmitted from the port.
2. Set the RS-232 mode bit field in the VARS menu. To get to the variable press, SETUP-MORE-VARS-ENTR and scroll to RS232_MODE, then press EDIT. The possible values are:

Table 7-1: RS-232 Port Setup - Front Panel

Decimal Value	Description
1	Turns on quiet mode (messages suppressed)
2	Places analyzer in computer mode (no echo of chars)
4	Enables Security Features (Logon, Logoff)
8	Enables RS-232 menus display on M100AH front panel display
16	Enables alternate protocol (i.e. Hessen) and setup menu
32	Enables multi-drop support for RTS

NOTE

To enter the correct value, ADD the decimal values of the features you want to enable. For example if LOGON and front panel RS-232 menus were desires the value entered would be 4 + 8 = 12.

7.1.2 Security Feature

The RS-232 port is often connected to a public telephone line which could compromise instrument security. If the LOGON feature is implemented the port has the following attributes:

1. A password is required before the port will operate.
2. If the port is inactive for 1 hour, it will automatically LOGOUT.
3. If not logged on, the only command that is active is the '?'. If this command is issued the M100AH will respond with MUST LOG ON.
4. The following messages will be given at logon.
   A. LOG ON SUCCESSFUL - Correct password given
   B. LOG ON FAILED - Password not given or incorrect
   C. LOG OFF SUCCESSFUL - Logged off

The RS-232 LOGON feature must be enabled from the front panel by setting bit 4. See Table 7-1. Once the feature is enabled, to logon type:

```
LOGON 940331
```

940331 is the default password. The password can be changed to any number from 0 to 999999 by the variable RS232_PASS. To change the password enter the command

```
V RS232_PASS=xxxxxx
```

which sets the password to the value xxxxxx.

7.1.3 Protocol of Port Communication

The RS-232 interface has two protocols of communication, because if the port is attached to a computer it needs to have different characteristics than if used interactively. Consequently, there are two primary styles of operation: terminal mode and computer mode.

When an operator is communicating with the analyzer via a terminal, the analyzer should be placed into TERMINAL MODE, which echoes keystrokes, allows editing of the command line using the backspace and escape keys, and allows recall of the previous command. When a host computer or data logger is connected to the analyzer, it should be placed into COMPUTER MODE, which does not echo characters received or allow the special editing keys.

Table 7-2: RS-232 Switching From Terminal Mode to Computer Mode

Key	Function
Control-T (ASCII 20 decimal)	Switch to terminal mode (echo, edit)
Control-C (ASCII 3 decimal)	Switch to computer mode (no echo, no edit)

If the command line doesn't seem to respond to keystrokes or commands, one of the first things you should do is send a Control-T to switch the command line interface into terminal mode. Also, some communication programs remove CTRL-T and CTRL-C characters from the byte stream, therefore these characters will not be sent to the analyzer. Check your communications program owners manual.

7.1.4 Entering Commands in Terminal Mode

In terminal mode, all commands must be terminated by a carriage return; commands are not processed until a carriage return is entered. While entering a command you may use the following editing keys:

Table 7-3: RS-232 Terminal Mode Editing Keys

Key	Function
CR (carriage return)	Execute command
BS (backspace)	Backspace one character to the left
ESC (escape)	Erase entire line
Control-R (ASCII 18 decimal)	Recall previous command
Control-E (ASCII 5 decimal)	Recall and execute previous command

Commands are not case-sensitive; you should separate all command elements (i.e. keywords, data values, etc.) by spaces.

Words such as T, SET, LIST, etc. are called keywords and are shown on the help screen in uppercase, but they are not case-sensitive. You must type the entire keyword; abbreviations are not accepted.

OBTAINING HELP

Typing "?" followed by Return or Enter will cause a help screen to be displayed.

7.2 Command Summary

The information contained in the rest of this section covers all of the normal commands that are required to operate the instrument from a remote terminal. If you are going to be writing computer programs to communicate with the M100AH (i.e., operating the port in COMPUTER MODE) we suggest that you order a supplementary manual "The RS-232 Interface", Teledyne API part number 01350. This manual shows additional features of the port designed to support a computer driven interface program.

There are 6 different types of messages output by the M100AH. They are grouped below by type in Table 7-4, Table 7-5, and Table 7-6. The meanings of the various messages are discussed elsewhere in the manual. The TEST, DIAGNOSTIC and WARNING messages are discussed in Section 10.1, 10.2. DAS and VARIABLES are discussed in Section 5.3.3 and 5.3.9. CALIBRATE is discussed in Section 8.

Table 7-4: RS-232 Interface Command Types

First Character	Message Type
C	Calibration status
D	Diagnostic
R	DAS report
T	Test measurement
V	Variable
W	Warning

Table 7-5: RS-232 Command Summary

Commands	Definition
?	Print help screen
T SET ALL	Enable display of all test variables during T LIST
T SET name	Display only NAME during T LIST
T LIST [ALL]	Print all test variables enabled with T SET or ALL warnings
T name	Print single test, "name" from Table 7-7
T CLEAR ALL	Disable T LIST, use with T SET name
W SET ALL	Enable display of all warnings during W LIST
W LIST [ALL]	Print warnings enabled with W SET or ALL warnings
W name	Print individual "name" warning from Table 7-8
W CLEAR ALL	Disable W LIST, use with W SET
C command	Execute calibration "command" from Table 7-10
D LIST	Prints all I/O signal values
D name	Prints single I/O signal value/state
D name=value	Sets variable to new "value"
D LIST NAMES	Lists diagnostic test names
D ENTER name	Enters and starts 'name' diagnostic test
D EXIT	Exits diagnostic mode
D RESET	Resets analyzer (same as power-on)
D RESET RAM	System reset, plus erases RAM. Initializes DAS, SO_2 concentration readings, calibration not affected.
D RESET EEPROM	System reset, plus erases EEPROM (RAM_RESET actions + setup variables, calibration to default values)
V LIST	Print all easy variable names from Table 10-5
V name	Print individual "name" variable
V name=value	Sets variable to new "value"
V CONFIG	Print analyzer configuration

Table 7-6: RS-232 Command Summary

Terminal Mode Editing Keys	**Definition**
V MODE	Print current analyzer mode
BS	Backspace
EXC	Erase line
^R	Recall last command
^E	Execute last command
CR	Execute command
^C	Switch to computer mode
Computer Mode Editing Keys	**Definition**
LF	Execute command
^T	Switch to terminal mode
Security Features	**Definition**
LOGON password	Establish connection to analyzer
LOGOFF	Disconnect from analyzer

General Output Message Format

Reporting of status messages for use as an audit trail is one of the two principal uses for the RS-232 interface. You can effectively disable the asynchronous reporting feature by setting the interface to quiet mode. All messages output from the analyzer (including those output in response to a command line request) have the format:

```
X DDD:HH:MM IIII MESSAGE
```

X is a character indicating the message type, as shown in the following table.

DDD:HH:MM is a time-stamp indicating the day-of-year (DDD) as a number from 1 to 366, the hour of the day (HH) as a number from 00 to 23, and the minute (MM) as a number from 00 to 59.

IIII is the 4-digit machine ID number.

MESSAGE contains warning messages, test measurements, DAS reports, variable values, etc.

The uniform nature of the output messages makes it easy for a host computer to parse them.

7.3 TEST Commands and Messages

Table 7-7: RS-232 Test Messages

Name	Message	Description
RANGE[1]	RANGE=xxxxx PPM[2]	Analyzer range
STABILITY	STABIL=xxxx.x PPM	Std. Deviation of last 25 SO_2 concentration values
VACUUM	PRES=xxx.x IN-HG-A	Reaction cell pressure
SAMPPRESS	PRES=xxx.x IN-HG-A	Sample pressure
SAMPFLOW	SAMPLE FL=xxx CC/M	Sample flow rate
PMTDET	PMT=xxxxxx MV	PMT output
UVDET	UV LAMP=xxxx MV	Instantaneous UV lamp reading
LAMPRATIO	LAMP RATIO=xx.x%	Ratio of UV lamp reading to calibrated UV lamp reading
STRAYLIGHT	STR LGT=xxx.x PPM	Stray light level
DARKPMT	DRK PMT=xx.x MV	PMT dark current in MV
DARKLAMP	DRK LMP=xx.x MV	UV detector dark current in MV
SLOPE	SLOPE=x.xxx	Calibration slope parameter
OFFSET	OFFSET=xxx.x MV	Calibration offset parameter
HVPS	HVPS=xxxxx V	High voltage power supply
DCPS	DCPS=xxxxxx MV	DC power supply
RCELLTEMP	RCELL TEMP=xxx C	Reaction cell temperature
BOXTEMP	BOX TEMP=xxx C	Internal box temperature
PMTTEMP	PMT TEMP=xxx C	PMT temperature
SO2	SO2=xxxx.x	SO_2 concentration
TESTCHAN[3]	TEST=xxxx.x MV	Test channel output
CLOCKTIME	TIME=HH:MM:SS	Time of day

[1]Displayed when single or autorange is enabled.

[2]Depends on which units are currently selected.

[3]Only if test channel is selected.

The T **command** lists TEST messages. Examples of the T command are:

T LIST	Lists test messages currently enabled with T SET
T LIST ALL	Lists all test messages
T RCELLTEMP	Prints the temperature of the reaction cell
T SO2CONC	Prints SO_2 concentration message
T LAMPRATIO	Prints Lamp Ratio

7.4 WARNING Commands and Messages

Table 7-8: RS-232 Warning Messages

Name	Message	Description
WSYSRES	SYSTEM RESET	Analyzer was reset/powered on
WRAMINIT	RAM INITIALIZED	RAM was erased
WSAMPFLOW	SAMPLE FLOW WARNING	Sample flow out of spec.
WSAMPPRESS	SAMPLE PRESSURE WARNING	Sample pressure below 15” Hg or above 35” Hg
WVACPRESS	VACUUM PRESSURE WARNING	Vacuum pressure below 1 in-Hg or above 10 in-Hg.
WPMT	PMT DET WARNING	PMT output above 4995 mV.
WUVLAMP	UV LAMP WARNING	UV lamp output is below 600 mV or above 4995 mV
WDARKCAL	DARK CAL WARNING	Dark PMT OR Dark UV lamp is above 400 mV
WPMTTEMP	PMT TEMP WARNING	PMT temperature too high/low
WRCELLTEMP	RCELL TEMP WARNING	Reaction cell temp. out of spec.
WBOXTEMP	BOX TEMP WARNING	Box temperature too high/low
WDYNZERO	CANNOT DYN ZERO	Dynamic zero cal. out of spec.
WDYNSPAN	CANNOT DYN SPAN	Dynamic span cal. out of spec.
WHVPS	HVPS WARNING	HVPS too high/low
WVFDET	V/F NOT INSTALLED	A/D board not installed or broken
WDCPS	DCPS WARNING	DC power supply output below 2300 mV or above 2700 mV

Whenever a warning message is reported on the analyzer display, if the RS-232 interface is in the normal mode (i.e. not in quiet mode) the warning message is also sent to the RS-232 interface. These messages are helpful when trying to track down a problem with the analyzer and for determining whether or not the DAS reports are actually valid. The warning message format is for example:

```
W 194:11:03 0000 SAMPLE FLOW WARNING
```

The format of a warning command is W command. Examples of warning commands are:

W LIST	List all current warnings
W CLEAR ALL	Clear all current Warnings

Individual warnings may be cleared via the front panel or the command line interface. To clear the sample flow warning shown above the command would be:

```
W WSAMPFLOW
```

7.5 CALIBRATION Commands and Messages

Table 7-9: RS-232 Calibration Messages

Message	Description
START ZERO CALIBRATION	Beginning IZS zero calibration
FINISH ZERO CALIBRATION, SO2[1]=xxxxx PPM	Finished IZS zero calibration
START SPAN CALIBRATION	Beginning IZS span calibration
FINISH SPAN CALIBRATION, SO2[1]=xxxxx PPM	Finished IZS span calibration
START MULTI-POINT CALIBRATION	Beginning multi-point calibration
FINISH MULTI-POINT CALIBRATION	Finished multi-point calibration
[1]Depends on which units are currently selected.	

Whenever the analyzer starts or finishes an Zero/Span calibration, it issues a status report to the RS-232 interface. If the RS-232 interface is in the normal mode, these reports will be sent. Otherwise, they will be discarded. The format of these messages is:

```
C DDD:HH:MM IIII CALIBRATION STATUS MESSAGE
```

An example of an actual sequence of calibration status messages is:

```
C DDD:HH:MM IIII START MULTI-POINT CALIBRATION

C DDD:HH:MM IIII FINISH MULTI-POINT CALIBRATION
```

There are several methods of both checking the calibration and calibrating the M100AH that are discussed in Section 8. The C command executes a calibration command, which may be one of the following:

Table 7-10: RS-232 Calibration Commands

Command	Description
C ZERO	Start remote zero calibration
C SPAN	Start remote span calibration
C LOWSPAN	Start remote low span calibration
C COMPUTE ZERO	Adjust remote zero calibration
C COMPUTE SPAN	Adjust remote span calibration
C EXIT	Terminate remote zero or span calibration
C ABORT	Abort calibration sequence
C ASEQ X	Initiate automatic sequence X if previously setup

7.6 DIAGNOSTIC Commands and Messages

When Diagnostic mode is entered from the RS-232 port, the diagnostic mode issues additional status messages to indicate which diagnostic test is currently selected. Examples of Diagnostic mode messages are:

```
D DDD:HH:MM IIII ZERO VALVE=ON

D DDD:HH:MM IIII ENTER DIAGNOSTIC MODE

D DDD:HH:MM IIII EXIT DIAGNOSTIC MODE
```

The following is a summary of the Diagnostic commands.

Table 7-11: RS-232 Diagnostic Command Summary

Command	Description
D LIST	Prints all I/O signal values. See Table 10-4 for Signal I/O definitions.
D name=value	Examines or sets I/O signal. For a list of signal names see Table 10-4 in Section 10. Must issue D ENTER SIG command before using this command.
D LIST NAMES	Prints names of all diagnostic tests.
D ENTER SIG D ENTER OT D ENTER ET D ENTER TASK	Executes SIGNAL I/O diagnostic test. Executes Optic Test diagnostic test. Executes Elect Test diagnostic test. Displays a listing of the tasks and their status. Use D EXIT to leave these diagnostic modes.
D EXIT	Must use this command to exit SIG, ET or OT Diagnostic modes.
D RESET	Resets analyzer software (same as power on).
D RESET RAM	Resets analyzer software and erases RAM. Erases SO_2 concentration values. Keeps setup variables and calibration. (same as installing new software version)
D RESET EEPROM	Resets analyzer software and erases RAM and EEPROM. Returns all setup variables to factory defaults, resets calibration value.

7.7 DAS Commands and Reports

RS-232 Commands

In addition to accessing the data acquisition system and the stored data from the instrument front panel, you can also access the data acquisition and the stored data from the RS-232 interface.

There are two RS-232 commands, listed in the table below.

Table 7-12: RS-232 DAS Commands

RS-232 DAS Commands	
Command	**Description**
D [id] PRINT [“name”]	Prints specified data channel’s properties
D [id] REPORT “name” [RECORDS=number] [COMPACT|VERBOSE]	Prints the data for the specified data channel

In all of the commands, brackets ([ ]) denote optional parameters. The ID parameter is the instrument ID, useful when the multi-drop protocol is being used. The NAME parameter is the data channel’s name. It must be enclosed in quotes (i.e. D PRINT “CONC”).

The RECORDS parameter of the REPORT command indicates how many records from the most recent record and prior to print. If the RECORDS parameter is not specified, all of the records are printed. The COMPACT and VERBOSE parameters of the REPORT command specify the report format.

RS-232 Reports

There are two basic kinds of RS-232 reports: data channel summary report, and data reports.

Data Channel Summary Format

When you press the **PRNT** button in the data channel edit menu, a report like the following is printed on the RS-232 channel:

SETUP PROPERTIES FOR CONC:

NAME:	CONC
EVENT:	ATIMER
STARTING DATE:	25-JUL-96
SAMPLE PERIOD:	000:00:01
REPORT PERIOD:	000:00:05
NUMBER OF RECORDS:	800
RS-232 REPORT:	ON
COMPACT REPORT:	OFF
CHANNEL ENABLED:	ON
CAL. HOLD OFF:	ON
PARAMETERS:	1

PARAMETER=CONC1, MODE=AVG, PRECISION=1

In this example, the data channel's NAME property is "CONC"; the EVENT property is ATIMER; the PARAMETERS property is 1 (indicating a single parameter); the NUMBER OF RECORDS property is 800, and the RS-232 REPORT property is ON. The list of parameters and their properties is also printed. Each data channel stores its data in a separate file in the RAM disk, and this property shows the file name.

Data Report Format

A data report format looks like the following:

```
D   31:10:06  0412  CONC  : AVG  CONC1=6.8 PPM
```

This report uses the traditional TELEDYNE API format of a leading first character ("D" in this example), a time stamp ("31:10:06"), and the instrument ID ("0412"). The other fields in the report are the data channel name ("CONC"), the sampling mode ("AVG"), the parameter ("CONC1"), the parameter value ("6.8"), and the units ("PPM").

If the RS-232 interface is in the quiet mode, then these reports are not printed, although they can be requested by a user or host computer at a later time.

7.8 VARIABLES Commands and Messages

Table 7-13: RS-232 Operating Modes

Mode	Description
ZERO CAL A	Automatic zero calibration
ZERO CAL R	Remote zero calibration
ZERO CAL M	Manual zero calibration
SPAN CAL A	Automatic span calibration
SPAN CAL R	Remote span calibration
SPAN CAL M	Manual span calibration
M-P CAL	Manual multi-point calibration
DIAG ELEC	Electrical diagnostic test
DIAG OPTIC	Optical diagnostic test
DIAG AOUT	D/A output diagnostic test
DIAG	Main diagnostic menu
DIAG I/O	Signal I/O diagnostic
DIAG RS232	RS232 output diagnostic
DIAG ERASE	Memory erase diagnostic
SETUP x.x	Setup mode (x.x is software version)
SAMPLE A	Sampling; automatic cal. Enabled
SAMPLE	Sampling; automatic cal. Disabled

The M100AH operational modes are listed above. To list the analyzer's current mode type:

V MODE Lists M100AH current operational mode

Model 100AH Internal Variables

The M100AH has a number of internal setup variables. Essentially all of these are set at time of manufacture and should not need to be changed in the field. A list of user accessible variables is shown in Table 10-5.

A list of variables and their settings can be requested over the RS-232 port by:

V LIST Lists internal variables and values

The output from this command is quite long and will not be shown here. The general format of the output is:

```
name = value warning_lo warning_hi <data_lo> <data_hi>
```

Where:

name	= name of the variable
value	= current value of variable
warning_lo	= lower limit warning (displayed if applicable)
warning_hi	= upper limit warning (displayed if applicable)
data_lo	= lower limit of allowable values
data_hi	= upper limit of allowable values

Variables can be changed. Before changing the settings on any variables, make sure you understand the consequences of the change. We recommend you call the factory before changing the settings on any variables. The general format for changing the settings on a variable is:

```
V LIST name[=value [warn_lo [warn_hi]]]
```

For example to change the warning limits on the box temperature type:

```
V BOX_SET 30 10 50
```

and the CPU should respond with:

```
V  DDD:HH:MM  IIII  BOX_SET=30 10 50(0-60)
```

The CONFIG command lists the software configuration.

For example:

V CONFIG list software configuration

The format of this listing is shown in the example below.

CONFIG[0] = Revision B.1

CONFIG[1] = SO_2 Analyzer

CONFIG[2] = SBC40 CPU

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8 CALIBRATION AND ZERO/SPAN CHECKS

There are several ways to check and adjust the calibration of the M100AH. These different methods are summarized in Table 8-1. In addition, most of the methods described in this section can be initiated and controlled via the RS-232 port. See Section 7 for details.

Table 8-1: Types of Zero/Span Checks and Calibrations

Section	Type of Cal or Check	Description
8.1	Manual Z/S Check - Cal gas through sample port	This calibration option expects the calibration gas to come in through the sample port. Zero/Span valves do not operate.
8.2	Manual Z/S Check or Calibration with Z/S valve Option	How to operate Zero/Span Valve Option. Can be used to check or adjust calibration.
8.3	Automatic Z/S Check with Z/S Valves	Operates Z/S valves once per day to check the calibration.
8.4	Dynamic Z/S Calibration with Z/S Valves	Operates Z/S valves once per day and adjusts the calibration.
8.5	Use of Z/S Valve with Remote Contact Closure	Operates Z/S valves with rear panel contact closures. Without valves can be used to switch instrument into zero or span cal mode. Used for either checking or adjusting zero/span.
8.6	Special calibration requirements for Dual Range or Auto Range	Covers special requirements if using Dual Range or Auto Range.
8.7	Calibration Quality	Information on how to determine if the calibration performed will result in optimum instrument performance.
8.8	Calibration gases	Recommendation for selecting calibration gases.

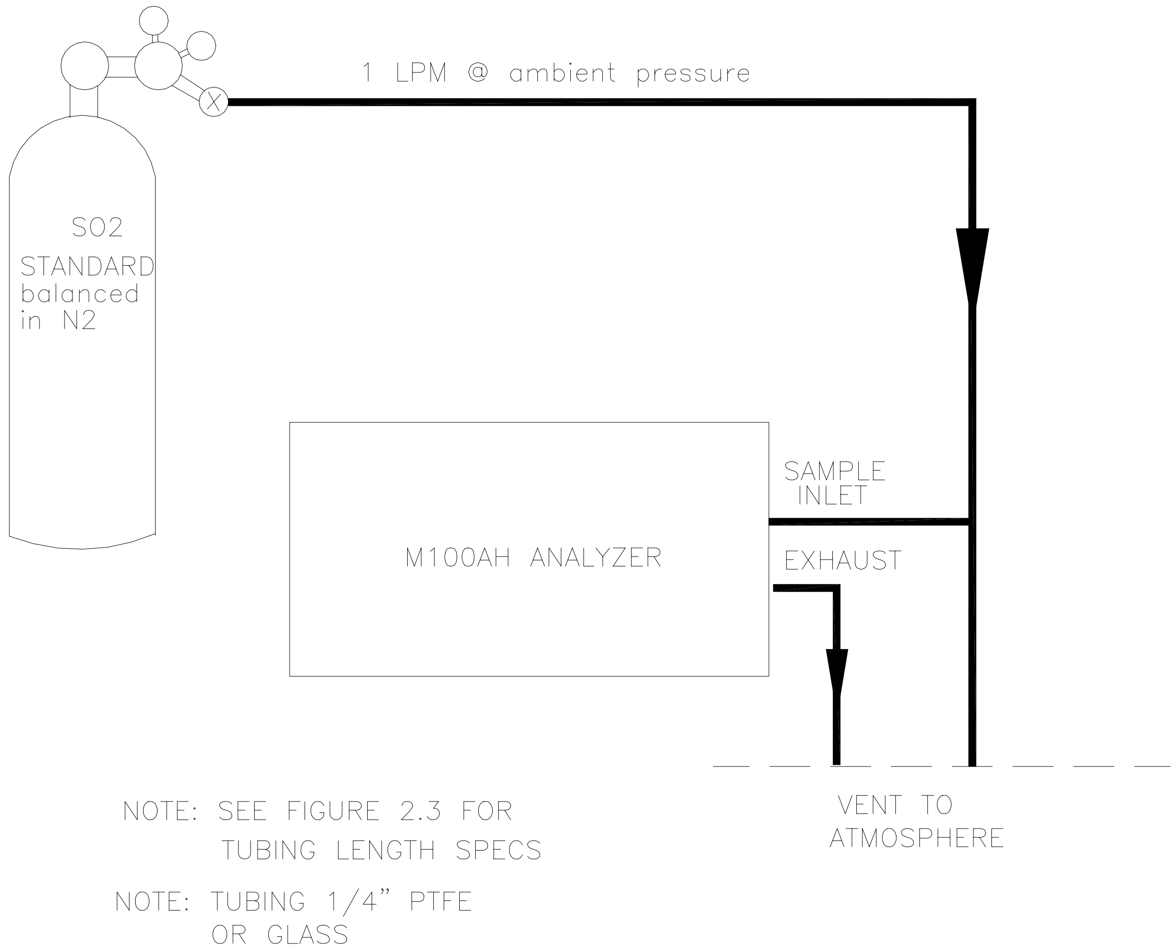

Figure 8-1: Model 100AH Calibration Setup

8.1 Manual Zero/Span Check or Calibration Through the Sample Port

The zero and span calibration of the instrument can be checked or adjusted using gases supplied through the normal sample port. This method is often used when the calibration gas is supplied from an external calibrator system.

This mode provides a calibration mechanism if the instrument is purchased without the Zero/Span Valve option.

Since the zero gas concentration is defined as 0 PPM, it is not necessary to enter the expected zero value. Table 8-2 details the zero calibrate procedure with zero gas coming in through the sample port.

Table 8-2: Manual Zero Calibration Procedure - Zero Gas Through Sample Port

Step Number	Action	Comment
1.	Press CAL	The M100AH enters the calibrate mode from sample mode. The zero gas must come in through the sample port. If AutoRange is enabled, then select LO or HI range and press ENTR.
2.	Wait 10 min	Wait for reading to stabilize at zero value
3.	Press ZERO	If you change your mind after pressing ZERO, you can still press EXIT here without zeroing the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M100AH returns to sampling. Immediately after calibration, data is not added to the DAS averages.

If the instrument will be used on more than one range such as AUTO RANGE or DUAL RANGE, it should be calibrated separately on each applicable range (see Section 8.6 for calibration procedure).

Enter the expected SO_2 span gas concentration:

Table 8-3: Enter Expected Span Gas Concentration Procedure

Step Number	Action	Comment
1.	Press CAL-CONC	This key sequence causes the M100AH to prompt for the expected SO_2 concentration. Enter the SO_2 span concentration value by pressing the key under each digit until the expected value is set. This menu can also be entered from CALS.
2.	Press ENTR	ENTR stores the expected SO_2 span value.
4.	Press EXIT	Returns instrument to SAMPLE mode.

Table 8-4: Manual Span Calibration Procedure - Span Gas Through Sample Port

Step Number	Action	Comment
1.	Press CAL	The M100AH enters the calibrate mode. External span gas should be fed to the sample port. If AutoRange is enabled, then select LO or HI range and press ENTR.
2.	Wait 10 min	Wait for reading to stabilize at span value.
3.	Press SPAN	If you change your mind after pressing SPAN, you can still press EXIT here without spanning the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calibration equations and causes the instrument to read the SO_2 span concentrations.
5.	Press EXIT	M100AH returns to sampling. Immediately after calibration, data is not added to the DAS averages.

8.2 Manual Zero/Span Check or Calibration with Zero/Span Valves Option

The Zero/Span valve option can be operated from the front panel keyboard. In the Zero/Span valve option the zero and span gas comes into the valves through ports on the rear panel of the instrument.

Table 8-5: Manual Zero Calibration Procedure - Z/S Valves

Step Number	Action	Comment
1.	Press CALZ	The analyzer enters the zero calibrate mode. This switches the zero valve to allow zero gas to come in through the zero gas inlet port on the rear panel. If AutoRange is enabled, then select LO or HI range and press ENTR.
2.	Wait 10 min	Wait for reading to stabilize at zero value.
3.	Press ZERO	If you change your mind after pressing ZERO, you can still press EXIT here without zeroing the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations, forcing the reading to zero.
5.	Press EXIT	M100AH returns to sample mode. Immediately after calibration, readings do not go into the DAS averages.

Table 8-6: Manual Span Calibration Procedure - Z/S Valves

Step Number	Action	Comment
1.	Press CALS	The M100AH enters the calibrate mode from sample mode. This operates the sample/cal and zero/span valves to allow span gas to come in through the cal gas inlet port or the rear panel. If AutoRange is enabled, then select LO or HI range and press ENTR.
2.	Wait 10 min	Wait for reading to stabilize at span value.
3.	Press SPAN	If you change your mind after pressing SPAN, you can still press EXIT here without spanning the instrument.
4.	Press ENTR	Pressing ENTR actually changes the calculation equations.
5.	Press EXIT	M100AH returns to sampling. After calibration, data is not added to the DAS averages during HOLDOFF period.

8.3 Automatic Zero/Span Check

M100AH can automatically check (AUTOCAL) its calibration each day. If provided with the proper option, the M100AH provides this capability by using the time of day clock to signal the computer system to check operations. When enabled, the instrument software will automatically check zero and span (AUTOCAL) on a timed basis. Optionally, the Z/S cycle can be moved backwards or forwards a fixed time each day (to avoid missing measurements at the same time each day).

Setup of the AUTOCAL is covered in Section 6.3.

8.4 Dynamic Zero/Span Calibration

The AUTOCAL system described above can also optionally be used to calibrate the instrument on a timed basis. The automatic calibration is enabled by setting CALIBRATE button to ON under each SEQUENCE setup (Refer Section 6.3). In addition of AUTOCAL setup, Dynamic Zero and/or Dynamic Span should be enabled. With Dynamic calibration turned on, the instrument will re-set the slope and offset values for the SO_2 concentration. To set DYN_ZERO or DYN_SPAN, press SETUP-MORE-VARS-ENTR and press NEXT repeatedly until DYN_ZERO is shown. Press EDIT and toggle OFF (disabled) or ON (enabled).

This continual re-adjustment of calibration parameters can often mask subtle fault conditions in the analyzer. It is recommended that if Dynamic Calibration (especially Dynamic Span) is enabled, the TEST functions, and SLOPE and OFFSET values in the M100AH should be checked frequently to assure high quality and accurate data from the instrument.

8.5 Use of Zero/Span Valves with Remote Contact Closure

The Zero/Span valve option can be operated using Remote Contact Closures provided on the rear panel. See Figure 2-2 for connector location and pinout. When the contacts are closed, the analyzer will switch to zero or span mode. The contacts must remain closed for at least 1 second, and the analyzer will remain in zero or span mode as long as the contacts are closed. If either DYN_ZERO or DYN_SPAN is enabled (refer Table 10-5), the calibration is adjusted at the end of the zero or span time, otherwise zero or span is just checked, not adjusted. To set DYN_ZERO or DYN_SPAN, press SETUP-MORE-VARS-ENTR and press NEXT repeatedly until DYN_ZERO is shown. Press EDIT and toggle OFF (disabled) or ON (enabled).

The CPU monitors these contact closures and will switch the analyzer into zero or span mode when the contacts are closed for at least 1 second.

In order to do another remote check, both contact closures should be held open for at least 1 second, then may be set again. Table 8-7 shows what type of check is performed based on the settings of the contact closures.

Table 8-7: Z/S Valves Mode with Remote Contact Closure

Ext Zero CC	Ext Low Span CC	Ext High Span CC	Operation
Contact Open	Contact Open	Contact Open	State when in SAMPLE mode, normal sample monitoring.
Contact Open	Contact Closed	Contact Open	Low Span check or calibrate*
Contact Closed	Contact Open	Contact Open	Zero check or calibrate*
Contact open	Contact Open	Contact Closed	High Span check or calibrate*

*Calibrate only if Dynamic Calibration is enabled (see Table 10-5).

8.6 Special Calibration Requirements for Dual Range or Auto Range

If Dual Range or Auto Range is selected, then it should be calibrated for both Low Range (Range1) and High Range (Range2) separately. Pressing CAL key will prompt Low Range and High Range keys for Range1 (Low Range) or Range2 (Hi Range) calibration selection. Select desired range number and press ENTR to proceed to the calibration. Once desired range is selected, the display will show Test Measurements and SO_2 concentration for the corresponding range. You must enter expected SO_2 gas concentrations separately per Table 8-3 procedure for each range.

For zero calibration allow zero gas through the sample port and proceed to manual zero calibration procedure per Table 8-2, step 2 through step 4. After zero calibration is set, switch to span SO_2 gas to continue for span calibration procedure per Table 8-4 step 2 through step 4. Press EXIT to exit from the current Range.

Repeat the above procedure for the other Range by pressing CAL key and selecting the Range as described above. Enter once again corresponding SO_2 gas concentration for selected Range and continue zero/span calibration for the other Range selected.

M100AH with Zero/Span Valves option can be used to calibrate zero/span of the desired Range. Pressing CALZ (for zero) or CALS (for span) keys will lead to show Low Range and High Range the same way as CAL key except CALZ is dedicated for zero air calibration while CALS is dedicated for span gas calibration.

8.7 Calibration Quality

After Zero/Span is complete, it is very important to check the QUALITY of the calibration. The calibration of the M100AH involves balancing several sections of electronics and software to achieve an optimum balance of accuracy, noise, linearity and dynamic range.

The following procedure compares the Slope and Offset parameters in the equation used to compute the SO_2 concentration.

The slope and offset parameters are similar to the span and zero pots on an analog instrument. Just as in the analog instrument, if the slope or offset gets outside of a certain range, the instrument will not perform as well.

The offset value gives information about the background signal level. Check the observed offset value against the factory value in Table 2-1. If significantly higher check Section 10.1.6. Increasing readings are a predictor of problems.

Table 8-8: Calibration Quality Check

Step Number	Action	Comment
1.	Scroll the TEST function menu until the SLOPE is displayed.	Typical SLOPE value for SO_2 is 1.0 ± 0.3. If the value is not in this range, check Section 10.1.6. If the SLOPE value is in the acceptable range the instrument will perform optimally.
2.	Scroll the TEST function menu until the OFFSET is displayed.	Typical number is less than 200mV which is mainly the optical system background. If the OFFSET value is outside this range, check Section 10.1.6.

After the above procedure is complete, the M100AH is ready to measure sample gas.

8.8 Calibration Gases

The following are recommended for selecting calibration gas:

1. Concentration of span gas should be about 80% of the full scale range if direct cylinder span gas is used without dilution. Also select reasonable range to operate for optimum instrument performance such as linearity , noise, etc. For example, if the typical sample concentration is about 300 PPM and the maximum peak concentration is about 800 PPM, then set the range to 1000 PPM and calibrate with 800 PPM of SO_2 gas. If the sample concentration is very low, then set the range low accordingly or use AUTORANGE (refer Section 5.3.4) feature.

2. Cylinder source SO_2 gas should be balanced in nitrogen and diluted with nitrogen (ultrazero grade). If diluted with dry zero air instead of nitrogen, it must be free of NO gas or other contaminants.

3. **Do not use blended gas of SO_2 and NO gas mixture in nitrogen.** NO gas in nitrogen interfere with the M100AH fluorescence SO_2 measurement. If the sample gas contains about 10% of CO_2, then the interference from the NO gas will be reduced significantly. M100AH is designed with special optical filter that rejects NO interference greater than 100 to 1 ratio. Therefore with the special optical filter and mixture of CO_2 gas in the sample will result very low NO gas interference.

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9 MAINTENANCE

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.

9.1 Maintenance Schedule

Table 9-1: Preventative Maintenance Schedule

Item	Maintenance Interval	Reference Section
TEST functions	Check every month	Table 10-1
Zero/Span Calibration	Weekly or as needed	Section 8
Zero/Span checks	Daily or a needed	Section 8, Table 6-2
Particulate Filter	Weekly as needed	Figure 9-1
Pump charcoal scrubber	Refill every 3 months	Section 9.3
Reaction cell cleaning	Clean annually or as necessary	Section 9.5, Figure 9-2
Sample Flow	Check every 6 months	Figure 9-3, Section 10.2.2
Pneumatic Lines	Examine every 12 months, clean if necessary	Figure 9-3
Factory Calibration	Calibrate each year or after repairs	Section 10.1.6
Leak Check	Check every 6 months	Section 9.7

9.2 Replacing the Sample Particulate Filter

The particulate filter should be inspected often for signs of plugging or contamination. It is also common for dirt particles to absorb SO_2, thus causing those readings to be lower than the actual value. A very dirty filter can cause serious monitoring problem such as very slow and low response, inability to span, and contamination of the analyzer. The particulate filter should be changed at a minimum every 2 weeks. If the instrument is operated under high dust environment, the particulate filter should be replaced more frequently.

To check and change the filter (refer to Figure 9-1):

1. Locate the filter on the rear panel of the analyzer, unscrew the hold-down ring and visually inspect the filter.
2. If the filter appears dirty, remove the o-ring and then the filter.
3. Replace the filter, being careful that the element is fully seated in the bottom of the holder. Replace the o-ring, then screw on the hold-down ring and hand tighten.

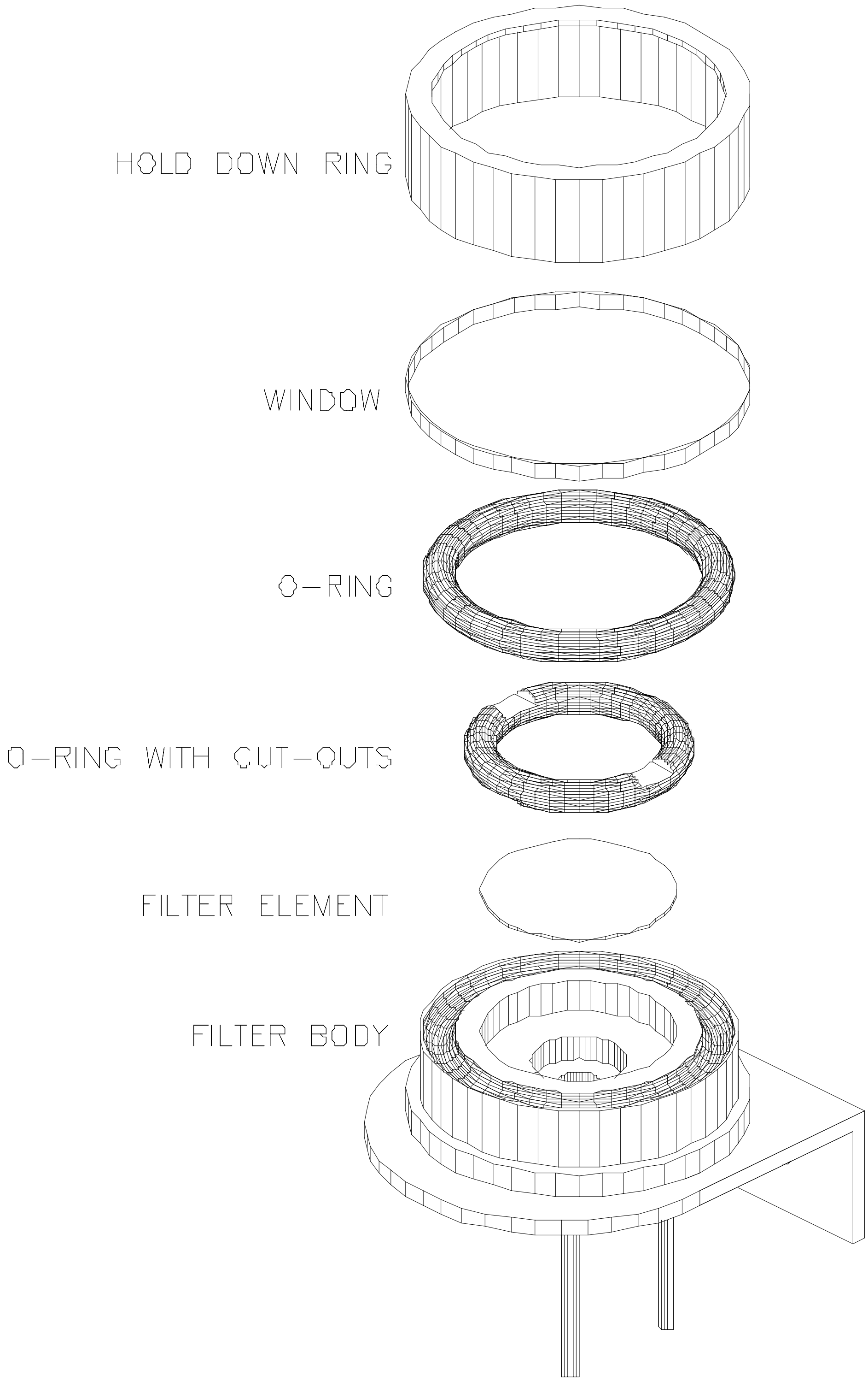


Figure 9-1: Replacing the Particulate Filter

9.3 Replacing the Pump Scrubber

The entire cartridge can be replaced, or just the charcoal inside of the cartridge. To replace the scrubber materials:

1. Disconnect the scrubber from the clip of bracket and remove the fitting that holds the DFU filter. While removing the cartridge, check the DFU filter for contamination and dirt. Replace it if necessary.
2. Unscrew the top, remove the felt pad and empty the contents.
3. Inspect the upper and lower felt pads for signs of plugging, replace if necessary.
4. Replace with charcoal.
5. Re-install the felt pad and re-tighten the cap. Make sure the o-ring in the cap is in good shape and squarely seated.
6. Leak check the assembly, then re-attach scrubber to fitting and clip on the bracket.

9.4 Cleaning Orifice and Orifice Filter

The sample flow across the internal pneumatic system is fixed by the critical flow control orifice and has no adjustment.

1. Turn off the instrument power.
2. Remove the elbow fitting toward rear panel only from the flow control module.
3. With a toothpick or paper clip, remove the spring, filter, o-ring , orifice, and the o-ring from each port.
4. Discard the filter.
5. Check the orifice by looking at it toward a light to see that the orifice itself is open. If it is not open, try cleaning the orifice with a strand of fine wire or immersing in a solvent such as methyl alcohol, or both.
6. If the orifice will not open, replace it.
7. Replace o-rings if they are deformed or suspected not to seat properly.
8. To replace the orifice, start with the o-ring, then orifice (jeweled end faces upstream), o-ring, filter, and finally spring.
9. Retape the fittings with TFE tape, install and tighten.
10. Leak check.

9.5 Cleaning the Reaction Cell

The reaction cell should be cleaned whenever troubleshooting points to it as the cause of the trouble (refer Figure 9-2). A dirty cell will cause excessive noise, unstable span or zero, high stray light, or slow response.

Use the following guide:

1. Turn off the instrument power.
2. Remove the three screws at the sensor shock absorber mounts.
3. Tilt the sensor up to provide access to the reaction cell cover.
4. Remove the cover carefully to avoid thermal silicon contamination on the o-ring and the cell.
5. Wipe out the reaction cell with a de-ionized water wetted lintless wipe. Dry with another lintless wipe.
6. Be sure that all lint particles are removed, particularly from the UV lens and PMT filter.
7. Install the cell cover.
8. Install the shock absorber mount screws.
9. Leak-check per Section 9.7.

9.6 Pneumatic Line Inspection

Particulate matter and contamination in the pneumatic lines will affect the response of the analyzer. It is important that the pneumatic system be periodically inspected and thoroughly cleaned if necessary. Clean by disassembling and passing methanol through three times. Dry with nitrogen or suitable clean zero air.

Also inspect all pneumatic lines for cracks and abrasion on a regular basis. Replace as necessary. Refer to the pneumatic diagram in Figure 9-3.

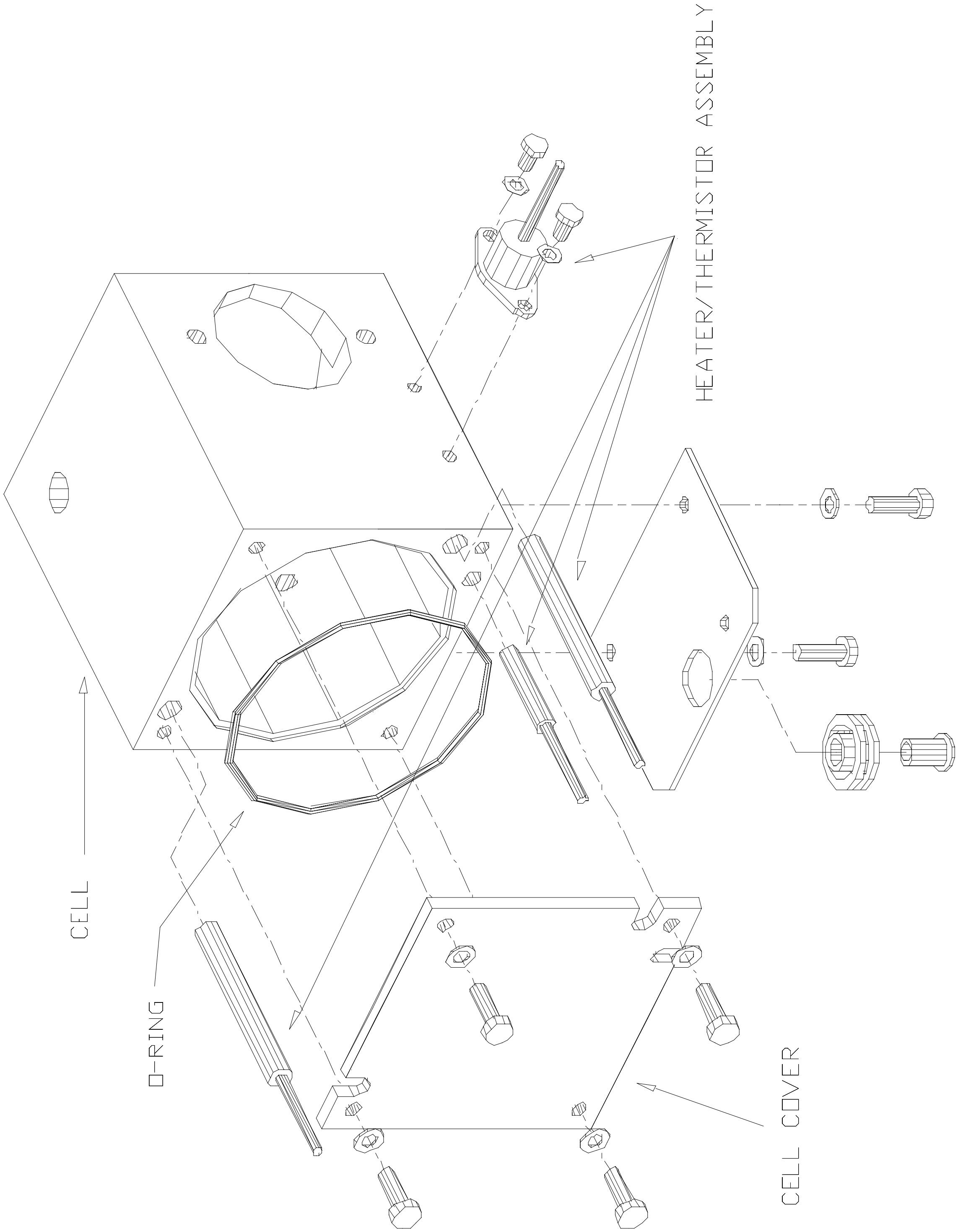
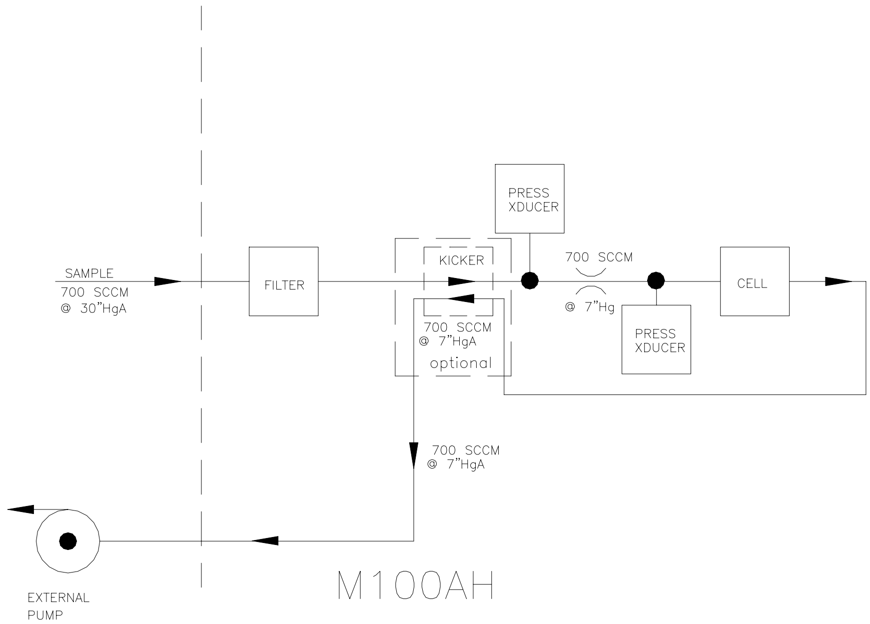


Figure 9-2: Reaction Cell



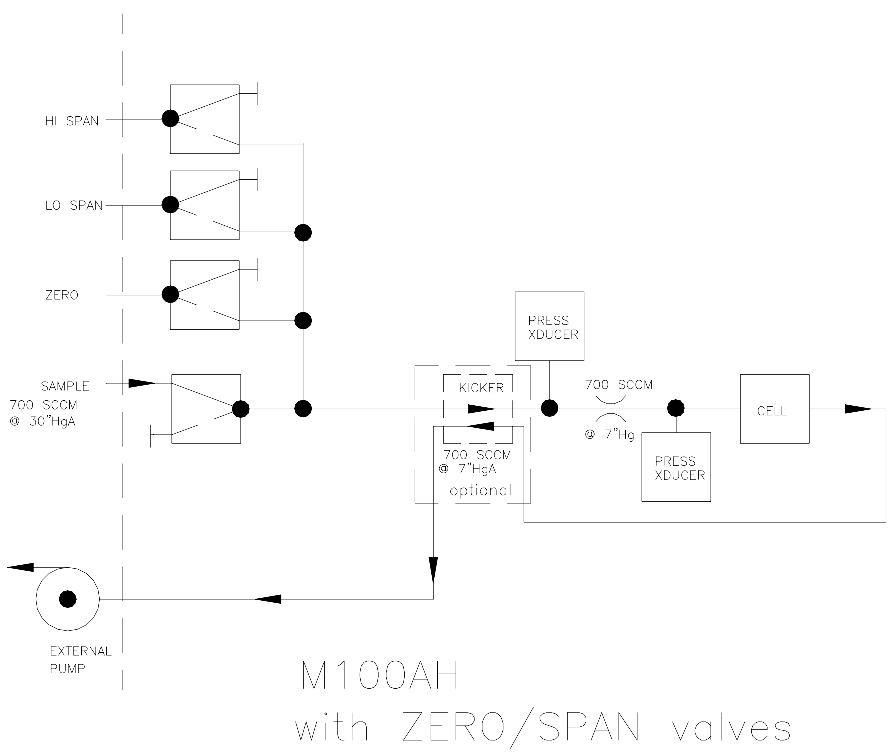


Figure 9-3: Pneumatic Diagram

9.7 Leak Check Procedure

There are two methods of leak checking. The vacuum method is the simplest but it does not show the location of a leak. This vacuum method described below is the general method when a Leak Checker is not readily available. The other method is the pressure method. This can be used to find the exact location of a leak by using bubble solution.

NOTE
Do not use a bubble solution during vacuum method as the solution may enter and contaminate the cell.

Vacuum method (general check):

1. Cap the sample inlet port.
2. Set the TEST function to VACUUM pressure. Wait for stable reading and record the reading.
3. Unplug the power cord of the pump.
4. Observe the VACUUM pressure reading for about 30 seconds. It should be close (±0.2 in-Hg) to the previous reading in step 2 if the pneumatic system including the pump is leak free.

The above method is a general method to check the pneumatic system when a leak checker is not available. The above test checks the sensor pneumatic leak including the pump and therefore the pump must be in good condition to hold the vacuum pressure. Perform the above test only when a leak checker is not available.

If a Leak Checker is readily available, then use it in place of the pump to pull the vacuum. After step 1 of above, pull the vacuum for about 20 in-Hg and close the shut off valve of the leak checker and turn off the pump. If the pressure changes more than 1 in-Hg within 5 minutes, there is a leak. It is not possible by the vacuum method to tell where the leak is located. See the pressure method below to locate the leak.

Pressure method:

1. Connect a Leak Checker to the exhaust port of the analyzer. (Refer to Figure 9-3 for pneumatic diagram.)
2. Pressurize the system and adjust the needle valve such that the gauge pressure does not exceed 15 PSIG.
3. Apply bubble solution to all the seals, interfaces and fittings to locate the leak.
4. Tighten the seal or fitting until the leak stops.
5. Lastly, drop off any accumulated bubble solution from the sensor assembly.
6. Verify leak by pressurizing the pneumatic system and close the shut-off valve. Turn off the pump power. If the gauge pressure drops more than 1 in-Hg within 5 minutes, then repeat steps 2 through 5 until the leak stops.

9.8 Light Leak Check Procedure

1. Scroll the TEST functions to PMT.
2. Input zero gas.
3. Shine a powerful flashlight or portable incandescent light at the inlet and outlet fitting, and at all the joints of the reaction cell. The PMT value should not respond to the light.

If there is a response, tighten the joints or replace the tubing with new black PTFE tubing.

9.9 EPROM Replacement Procedure

1. Turn the instrument power off.
2. Remove the hold down screw that holds in the V/F-CPU assembly to the motherboard. Disconnect the J9 power connector from the motherboard. Gently lift the assembly far enough out of the instrument to remove the connector from the display and the RS-232 connector.
3. The CPU board is attached to the larger V/F board.
4. Remove the board, laying it down on an insulating surface such that the board edge pins on the PCB are on the left. The EPROM chip should be at the top center. The current chip should be labeled with something like "M100AH B.1 - - -". See Figure 10-1 for location of prom on CPU card. Gently pry the chip from its socket and replace it carefully with the new chip. Install the chip in the left end of the socket with the notch facing to the right. Make sure that all of the legs insert into the socket correctly.
5. Re-attach the CPU board to the V/F board, and re-attach the assembly to the motherboard.
6. Turn the M100AH ON and observe the front panel display. As the machine goes through the setup the version number will be displayed on the front panel. It should read the same as the version number printed on the prom.
7. All setup variables are stored in the E^2PROM and should not be affected while changing EPROM. Check all settings to make sure that expected setup parameters are present.
8. Re-calibrate the machine so that the default slope and offset are entered.

10 DIAGNOSTIC, TROUBLESHOOTING

> **NOTE**
>
> **The operations outlined in this chapter are to be performed by qualified maintenance personnel only.**

This section of the manual contains information on diagnosing and corrective action procedure for the instrument performance problems. It contains information on how to use and interpret TEST and DIAGNOSTIC data as well as WARNING messages the instrument generates. There is information on how to troubleshoot the instrument subsystems. Finally there is information to perform adjustments such as DAC calibration procedures.

This manual provides troubleshooting procedures that address problems to the board level. For component level troubleshooting, consult the schematics for the appropriate board in Appendix A.1.

> **NOTE**
>
> **The values of the readings shown on the front panel of the instrument may at times read XXXXXX. This means that the reading is off scale and therefore meaningless.**

General Troubleshooting Hints

Think of the analyzer as three sections to isolate the cause of the problems:

Section 1 - Pneumatics - Over 50% of all analyzer problems are traced to leaks in the pump, sample filter, instrument internal pneumatics, calibrator or external sample handling equipment.

Section 2 - Electronics - data processing section. This can be readily checked out using Electric Test in Section 10.1.3.2.

Section 3 - Optics - Optical section consisting of PMT, HVPS, Preamp, and signal processing. Refer to Section 10.1.3.3 on use of Optical Test.

Check the TEST functions:

1. Compare the TEST functions to the factory values in Table 2-1. This will often provide important clues as to the problem.

2. Check for the sign of the drift, particularly the slope and offset readings:

   The slopes are the software equivalent of the span pot on an analog instrument. If the slopes are not 1.0 ± 0.2, the gain has changed, usually from:

   A. Possible causes for the drift or change of the slope are:
      1) PMT HVPS change
      2) Incorrect span gas concentration
      3) Pneumatic leak such as sample filter, pneumatic lines, reaction cell, etc.
      4) UV Lamp output change
      5) Reaction cell pressure change

   B. Possible causes for the drift or change of offset are:
      1) Pneumatic leak
      2) Light leak
      3) UV filter damaged
      4) Incorrect zero gas

3. Incorrect span gas concentration - this could come either from the calibrator or entering the expected span gas concentration in the M100AH incorrectly. See Table 8-3.

4. If the instrument does not respond to span gas, check Section 10.2.3.

The above should get you started in diagnosing and troubleshooting the most common faults. If these reasons have been eliminated, the next thing to do is a Factory Calibration covered in Section 10.1.6 or check Section 10.2 for other fault diagnosis. If difficulties persist contact our service department. The 800 telephone number is on the cover page of this manual.

10.1 Operation Verification - M100AH Diagnostic Techniques

10.1.1 Fault Diagnosis with TEST Variables

The Table 10-1 indicates possible fault conditions that could cause the TEST functions to be outside the acceptable range.

Table 10-1: Test Functions

Test Function	Factory Set-Up	Comment
RANGE	500 PPM	This is the Range of the instrument. In standard configuration all 2 outputs have the same range. Dual range option allows different ranges for each output. When enabled, there will be 2 range values displayed (low range and high range). Auto range option allows 2 different ranges for each channel, and will automatically switch to the other range dynamically as concentration values require. The TEST values will show the range in which the instrument is currently operating, and will dynamically display the alternate range as the range changes occur.
STABIL		The instrument stability is computed for 25 samples with 10 seconds default interval time. The stability value should be compared to the value observed in the factory check-out. During normal sampling, this value will be changing depending on the sample concentration variation. Faults that cause high stability values are: 1. Pneumatic leak 2. Low (below 600 mV) or very unstable UV lamp output 3. Light leak 4. Faulty HVPS 5. Defective Preamp board (02107) 6. Aging detectors 7. PMT recently exposed to room light 8. Dirty/contaminated reaction cell

(table continued)

Table 10-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
VACUUM	Check value in Final Test Values Table 2-1	Reaction cell pressure is measured to monitor sample pressure and to compensate any sample pressure variation. Faults are caused due to: 1. Pump not able to pull the vacuum 2. Faulty pressure sensor 3. Sample line flow restriction 4. Faulty orifice assembly See Section 10.3.5 Pres/Flow Sensor.
PRES	Check value in Final Test Values Table 2-1	Inlet sample pressure is typically 1 In-Hg lower than the ambient pressure due to the internal pressure drop. Faults are caused due to: 1. Inlet pressure too high 2. Faulty pressure sensor 3. Sample line flow restriction See Section 10.3.5 Pres/Flow Sensor.
SAMP FL	650 cc/min ±65	This is the instrument flow. It is computed value from the upstream and downstream of the orifice. Incorrect flow can be caused by the plugged orifice, pneumatic leak, or the flow meter itself. If the orifice is plugged, computed value could give a false flow indication. - A rapid method of determining if the orifice is plugged is to disconnect the sample inlet from the filter assembly cell, then briefly put your finger over the fittings on the filter. You should feel the vacuum build up. - Another reliable method is to attach a rotameter or soap bubble flowmeter to the sample filter inlet fitting to measure the flows. Flow rate will change ± a few cc/min due to changes in sample pressure. Changing altitude changes the ambient air pressure and therefore the sample flowrate. See Section 10.2.2 Flow Check.

(table continued)

Table 10-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
PMT	0 - 5000 mV	This is the instantaneous output of the PMT. The PMT voltage values will be relatively constant when: 1. Electric test - variation in the 2000 mV signal observed will be noise of the V/F board and preamp noise. See Section 10.1.3.2. 2. Optic test - variation in the 400 mV signal will be PMT dark current, preamp, HVPS, and electronic. See Section 10.1.3.3. 3. Sampling zero gas. 4. Sampling stable SO_2 span gas. When sampling zero gas the PMT reading should be less than 50 mV and relatively constant. High or noisy readings could be due to: 1. Pneumatic leak. 2. Excessive background light which is caused by a possible aging UV filter. 3. Low UV lamp output. 4. PMT recently exposed to room light. It takes 24-48 hours for the PMT to adapt to dim light. 5. Light leak in reaction cell. 6. Reaction cell contaminated. 7. Vacuum pressure reading not stable. 8. HVPS not stable.

(table continued)

Table 10-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
UV LAMP	3000 - 4000 mV	This is the instantaneous reading of the UV lamp intensity. Typical UV lamp intensity is between 2000 mV and 4000 mV. See Section 10.4.2 for how to peak the UV lamp output. Intensity lower than 600 mV will cause WARNING and below 350 mV will cause to display XXXXX.X. Low UV lamp intensity could be due to: 1. Aging UV lamp. 2. Beam splitter out of alignment. 3. Faulty lamp transformer. 4. Aging or faulty UV detector. 5. Dirty optical components.
LAMP RATIO	80 - 120%	This is the computed value which is the ratio of current UV LAMP reading respect to the calibrated UV LAMP reading. Usually the ratio value drops as the aging lamp output decays. Low LAMP RATIO can cause the slope and offset out of typical range. See Section 10.4.2 how to reset the lamp calibration and LAMP RATIO.
STR LGT	<50 PPM	Stray light is the background light of the reaction cell expressed in PPM while sampling zero gas. High stray light could be caused by : 1. Aging UV filter. 2. Contaminated reaction cell. 3. Light leak. 4. Pneumatic leak.
DRK PMT	-50 ± 200 mV	This is the reading of the PMT signal without the UV lamp. When the lamp is momentarily turned off, the darkness inside of the reaction cell is monitored and compensated for any UV detector dark current drift or offset. High dark PMT reading could be due to: 1. Light leak. 2. Lamp not turning off completely. 3. High PMT temperature. 4. High electronic offset.

(table continued)

Table 10-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
DRK LMP	-50 ± 200 mV	This is the reading of the UV reference detector without the UV lamp. When the is momentarily turned off, UV detector signal is the dark current of the detector itself. The dark current is monitored and compensated for any UV detector dark current drift or offset. High dark UV detector could be caused by: 1. Lamp not turning off completely. 2. High electronic offset.
SLOPE	1.0 ± 0.2	The slope can be thought as a gain term which determines the steepness of the calibration curve. M100AH will operate normally even the slope is out of range, however it is preferred within the range for optimum operation of the analyzer. Slope out of range could be due to: 1. Analog gain pot needs adjustment (see Section 10.1.6). 2. Poor calibration quality (see Section 8.7).
OFFSET	<50 mV	This is essentially identical to the stray light except it is expressed in mV. High offset could be due to: 1. Light leak. 2. Aging UV filter. 3. Contaminated reaction cell. 4. Pneumatic leak. 5. Poor calibration quality.
HVPS	400 - 900 V	This represents the scaled-up HVPS programming voltage to the HVPS. The design of the HVPS precludes taking a single reading that indicates the health of the supply. Refer to the HVPS Troubleshooting Section 10.3.9 for a procedure for testing the HVPS. This TEST function is used primarily to set the HVPS voltage value and the reading should be very stable and constant. A value not in the 400 to 900 volt range indicates problems with the HVPS supply.

(table continued)

Table 10-1: Test Functions (Continued)

Test Function	Factory Set-Up	Comment
DCPS	2500 ± 200 mV	DCPS is a composite of the +5 and ± 15 VDC supplies. It has been arbitrarily set at 2500 ± 200 mV. If it is not in this range one of the voltages in the supply is not working. Check the procedures for diagnosing the Power Supply Module.
RCELL TEMP	50.0 ± 1°C	The reaction cell temperature is controlled to 50°C ± 1°C by the computer. It should only read other values when the instrument is warming up. If the value is outside the acceptable range, go to the procedure for diagnosing the Reaction cell temp supply. The alarm limits are less than 45°C and greater than 55°C.
BOX TEMP	8 - 48°C	The Box Temp is read from a thermistor on the Status/Temp board (01086). It should usually read about 5°C above room temp. The M100AH is designed to operate from 5 to 40°C ambient. Therefore the box temperature should be in the range of about 10 to 50°C. Temperatures outside this range will cause premature failures of components, and poor data quality. Warning limits are < 8°C and > 52°C.
PMT TEMP	7.0 ± 1°C	The PMT detector is very temperature sensitive. The PMT temperature should always be near 7°C, except at power-up. Temperatures more than ± 1°C from the set point indicate problems with the cooler circuit. See Section 10.3.9 for PMT cooler diagnostic and troubleshooting. Warning limits are < 2°C and > 12°C.
TIME		This is the time of day clock readout. It is used to time the AutoCal cycles. The speed of the clock can be adjusted by the CLOCK_ADJ variable in the VARS menu. The clock can be set via SETUP-CLOCK-TIME from the front panel.

10.1.2 Fault Diagnosis with WARNING Messages

The M100AH monitors several internal values for alarm conditions. If the condition for an alarm is met, the alarm is displayed on the front panel and the warning is transmitted out the RS-232 port. Any time the instrument is powered up the SYSTEM RESET alarm will be displayed. Generally, it is ok to ignore warnings that are displayed shortly after power-up; only if they persist should they be investigated.

Table 10-2 shows the warning messages and gives some possible causes.

Table 10-2: Front Panel Warning Messages

Message	Description
SYSTEM RESET	Analyzer was reset/powered on. This warning occurs every time the instrument is powered up, as in a power failure. It can also occur if the RAM or EEPROM is reset.
RAM INITIALIZED	RAM was erased. The RAM contains the DAS averages which get erased when the RAM is initialized. It also contains temporary data used by the M100AH to calculate concentrations. No setup variables are stored in the RAM.
PMT DET WARNING	The PMT output above 4995 mV. The Preamp circuit could be out of adjustment or wrong range selected.
UV LAMP WARNING	The UV lamp output is below 600 Mv or above 4995 Mv. UV lamp could be aging or need to peak output by adjusting the position. Also beam splitter out of alignment will cause to read lower.
DARK CAL WARNING	Dark PMT or UV lamp reading is above 400 mV.
HVPS WARNING	The HVPS control voltage is above 900 V or below 400 V. The Preamp circuit could be out of adjustment or the PMT sensitivity is too weak.
SAMPLE FLOW WARNING	The measured sample flow is outside the hi/low limits. A Leak in the pneumatic system is the main cause of the warning although the flow sensor itself could be the cause.
SAMPLE PRESS WARNING	The sample pressure is below 15”Hg or above 35”Hg.

(table continued)

Table 10-2: Front Panel Warning Messages (Continued)

Message	Description
VACUUM PRESSURE WARNING	The vacuum pressure is below 1 in-Hg or above 10 in-Hg.
BOX TEMP WARNING	Box temp. out of spec. Instrument fan failure, enclosure temperature failure. Operation of the M100AH in a too warm or cold environment will cause degradation of data quality and shorten the life of the instrument.
RCELL TEMP WARNING	Reaction cell temp. out of spec. The warning message is most often present during initial warm-up or poor electrical contact.
PMT TEMP WARNING	PMT temp. out of spec. The PMT temp has its own control circuit on the preamp (02107) board. Warnings will occur during initial warm up period. The warning can occur if the 7 pin connector to the interior of the sensor is not plugged in. The power from the PSM should be checked for proper voltage (+15 VDC ± 0.5) on the TEC driver circuit mounted on the fan duct. Test point 1 and test point 4 (white) should measure 15 VDC and LED should light brightly.
CANNOT DYN ZERO	Dynamic zero cal. out of spec. The reading of the PMT was too high for the ZERO button to appear. Make sure the instrument is receiving zero gas. Check for dirty reaction cell. Do the factory calibration procedure located in Section 10.1.6.
CANNOT DYN SPAN	Dynamic span cal. out of spec. The reading of the PMT was too high or low for the SPAN button to appear. Make sure the instrument is receiving correct concentration span gas. Make sure the expected span concentration is entered. Check for dirty reaction cell. Do the factory calibration procedure located in Section 10.1.6.
V/F NOT INSTALLED	V/F (00514) board has failed. The V/F board did not respond to commands from the CPU. This probably means: 1. board not seated in socket 2. defective board 3. defective back plane connector
DCPS WARNING	DC power supply output is put of specification. Test measurement display is below 2300 mV or above 2700 mV. Refer Section 10.3.4.

10.1.3 Fault Diagnosis using DIAGNOSTIC Mode

Diagnostic mode can be looked at as a tool kit of diagnostics to help troubleshoot the instrument.

To enter DIAG mode press:

`SETUP-MORE-DIAG`

The diagnostic modes are summarized in Table 10-3. To access these functions, after you have pressed SETUP-MORE-DIAG, then press NEXT, PREV to select the desired mode then press ENTR to select that mode. Table 10-3 contains a summary of the diagnostic modes and their operation. This section is a detailed description of the tests and suggestions for this use.

Table 10-3: Summary of Diagnostic Modes

DIAG Mode	Description
SIGNAL I/O	Gives access to the digital and analog inputs and outputs on the V/F board. The status or value of all of the signals can be seen. Some of the signals can be controlled from the keyboard. Table 10-4 gives details on each signal and information on control capabilities. NOTE: Some signals can be toggled into states that indicate warnings or other faults. These settings will remain in effect until DIAG mode is exited, then the M100AH will resume control over the signals.
ANALOG OUTPUT	Causes a test signal to be written to the analog output DAC's. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the % display to hold that value. The exact voltage values depend on the jumper settings on the analog output buffer amplifiers.
DAC CALIBRATION	The analog output is created by 4 digital-to-analog converters. This selection starts a procedure to calibrate these outputs. Refer to Section 10.3.2.1 for a detailed procedure.
OPTICAL TEST	Sets the M100AH into a known state and turns on an LED near the PMT to test the instrument signal path. See Section 10.1.3.3 for details on using this test.
ELECTRICAL TEST	Tests just the electronic portion of the PMT signal path. Used in conjunction with optic test, see Section 10.1.3.2.
LAMP CAIBRATION	This feature allows to update the Lamp Calibration value. Displayed value is the current lamp intensity and pressing ENTR key will update the Lamp Calibration value. Refer Section 10.4.2 for UV Lamp adjustment. See also Section 10.1.6 Factory Calibration Procedure.
FLOW CALIBRATION	This feature allows to enter the actual sample flow. Once the flow is calibrated, it will compute the flow automatically from the pressure measurements. Refer Section 10.3.5.
TEST CHANNEL OUTPUT	This feature allows to output scaled voltage of most test measurement through the analog output terminal. Refer Section 10.1.5.
RS-232	Causes a 1 second burst of data to be transmitted from the RS-232 port. Used to diagnose RS-232 port problems. See Sections 10.1.3.6 and 4.3.1.2 for RS-232 port diagnostic techniques.

10.1.3.1 Signal I/O Diagnostic

Table 10-4: Diagnostic Mode - Signal I/O

No.	Signal	Control	Description
0.	DSP_BROWNOUT	NO	Display brownout is used to keep the display from getting corrupted during low line voltage conditions. Circuitry on the Status/Temp board (01086) senses low line voltage and sets this bit. The CPU reads this and generates the BROWNOUT_RST signal described below.
1.	EXT_ZERO_CAL	NO	Shows state of status input bit to cause the M100AH to enter Zero Calibration mode. Use to check external contact closure circuitry.
2.	EXT_SPAN_CAL	NO	Shows state of status input bit to cause the M100AH to enter the Span Calibration mode. Use to check external contact closure circuitry.
3.	EXT_LOW_SPAN	YES	Shows state of status input bit to cause the M100AH to enter the Low Span Calibration mode. Use to check external contact closure circuitry.
4.	ZERO_VALVE	YES	Switches the Zero valve. Use this bit to test the Zero valve function.
5.	CAL_VALVE	YES	Switches the Sample valve. Use this bit to test the valve function.
6.	HIGH _SAPN_VALVE	YES	Energizes the high span valve. Use this bit to test the valve function.
7.	RCELL_ HEATER	NO	Shows the status of the reaction cell heater. This has the same function as the LED in the power supply module.
8.	ELEC_TEST	YES	Turns on electric test bit in Preamp. Should be used for troubleshooting Preamp circuit. We recommend you use the ELEC TEST button in the DIAG menu to operate electric test.
9.	OPTIC_TEST	YES	Turns on optic test bit in Preamp. Should be used for isolating PMT detector system from the rest of the Preamp circuit. We recommend you use the OPTIC TEST button in the DIAG menu to operate optic test.

(table continued)

Table 10-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
10.	BROWNOUT_RESET	YES	Brownout reset works in conjunction with DSP_BROWNOUT. When DSP_BROWNOUT is set the CPU sends a signal to reset the display and clear the DSP_BROWNOUT.
11.	ST_LAMP_ALARM	YES	Status Bit - UV Lamp alarm Logic High = UV lamp output too low Logic Low = Lamp output normal
12.	LOW_SPAN_VALVE	YES	Energizes the low span valve. Use this bit to test the valve function.
13.	ST_HIGH_RANGE	YES	Status Bit - Autorange High Range Logic High = M100AH in high range of autorange mode Logic Low = M100AH in low range of autorange mode
14.	ST_LOW_SPAN_CAL	YES	Status Bit - Low Span Calibration mode Logic high = M100AH in Low Span cal mode Logic low = Not in Low Span cal mode
15.	PRMP_RNG_HI	YES	Switches the preamp (02107) hardware range. Standard ranges are 500 and 5,000 PPM. Logic high = 5,000 PPM; logic low = 500 PPM. M100AH will reset range to correct value based on user set range value.
16.	ST_ZERO_CAL	YES	Status Bit - Zero Calibration mode Logic high = M100AH in Zero cal mode Logic low = Not in Zero cal mode
17.	ST_SPAN_CAL	YES	Status Bit - High Span Calibration mode Logic high = M100AH in High Span cal mode Logic low = Not in High Span cal mode
18.	ST_FLOW_ALARM	YES	Status Bit - Flow alarm Logic High = Sample flow out of spec Logic Low = Flows within spec

(table continued)

Table 10-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
19.	ST_TEMP_ALARM	YES	Status Bit - Temperature alarm Logic High = Reaction cell, PMT, Box temps out of spec Logic Low = Temps within spec
20.	ST_DIAG_MODE	YES	Status Bit - In Diagnostic mode Logic High = M100AH in Diagnostic mode Logic Low = Not in Diag mode
21.	ST_POWER_OK	YES	Status Bit - Power OK Logic High = Instrument power is on Logic Low = Instrument power is off
22.	ST_SYSTEM_OK	YES	Status Bit - System OK Logic High = No instrument warning present Logic Low = 1 or more alarm present
23.	ST_HVPS_ALARM	YES	Status Bit - HVPS alarm Logic High = HVPS out of spec Logic Low = HVPS within spec
24.	PMT_SIGNAL	NO	Current PMT voltage. Same as PMT voltage in TEST menu. Bi-polar, typically in 0-5000 mV range. A constant value of 5000 mV indicates off scale.
25.	RCELL_TEMP	NO	Reaction Cell temperature. 3500 mV for 50°C.
26.	BOX_TEMP	NO	Box Temperature. Typically 1800 mV for 25°C.
27.	PMT_TEMP	NO	PMT cold block temperature. Typically 1800 mV for 7°C.
28.	DCPS_VOLTAG	NO	DC power supply composite voltage output. Typically 2500 mV.
29.	SAMPLE_PRES	NO	Sample inlet pressure in mV. Typical sea level value = 3750 mV for 29.9" HG-A.
30	VACCUM_PRESS	NO	Reaction cell pressure in mV. Typical value = 750 mV for 6" HG.

(table continued)

Table 10-4: Diagnostic Mode - Signal I/O (Continued)

No.	Signal	Control	Description
31.	HVPS_VOLTAG	NO	HVPS programming voltage. Output of HVPS is 1000x value present.
32.	DAC_CHAN_0	NO	Output of SO_2 (DAC0/RANGE1) in mV.
33.	DAC_CHAN_1	NO	Output of SO_2 (DAC1/RANGE2) in mV.
34.	DAC_CHAN_2	NO	Output of spare (DAC2) channel in mV.
35.	DAC_CHAN_3	NO	Test Channel (DAC3) output.
36.	UVLAMP_SIGNAL	NO	Current UV lamp signal voltage in mV. Same as UV LAMP in TEST menu. Bi-polar, typically 0-5000 mV range. A constant value of 5000 mV indicates off scale.
37.	CONC_OUT_1	YES	DAC0 (SO2/RANGE1) analog output in mV.
38.	CONC_OUT_2	YES	DAC1 (SO2/RANGE2) analog output in mV.
39.	TEST_OUTPUT	YES	DAC3 (TEST CHANNEL) analog output in mV.

10.1.3.2 Electric Test

This function injects a constant voltage between the preamplifier and the buffer amplifier on the preamp board. Electric test checks part of the Preamp, the V/F and computer for proper functioning. The result of electric test should be a smooth quiet signal as shown by constant values for the SO_2 concentration. Likewise the analog outputs should produce a smooth quiet trace on a strip chart (analog output range is set to 5000PPM and auto-ranging is disabled).

Procedure:

1. Scroll the TEST function to PMT.
2. Press SETUP-MORE-DIAG, scroll to ELECT TEST by pressing the NEXT button. When ET appears, press ENTR to turn it on.
3. The value in PMT should come up to 2000 mV ± 100 mV in less than 15 sec.

If the HVPS or the span gain adjust on the preamp card has been changed without doing a FACTORY CALIBRATE the reading in step 3 may be different than 2000 mV, since the overall calibration affects ELECTRIC TEST. See Section 10.1.6 for factory calibration procedure.

4. To turn off ET press EXIT

If ET is a steady 2000 ± 100 mV, that means the Power Supply Module, Preamp buffer amplifier, V/F, CPU, and display are all working properly.

10.1.3.3 Optic Test

Optic test turns on a small LED inside the PMT housing which simulates the signal from the reaction cell. OT tests the entire signal detection subsystem. By observing the level, noise and drift of this test, correct operation of many sections of the analyzer can be verified.

The implementation of OT involves several changes to the instrument operating conditions. The M100AH does the following when switching to optic test:

1. Save the current instrument setup as to autorange, dual range, current range. D/A analog output is set at 5000 PPM range and auto-ranging is disabled.
2. Manually allow to sample zero gas to avoid unwanted sample measurement.
3. Select SETUP-MORE-DIAG, scroll to select the optic test and push ENTR button.
4. The PMT reading in TEST functions should be 200 ± 20 mV.

If the HVPS or the span gain adjust on the preamp card has been changed without doing a FACTORY CALIBRATE, the reading in step 4 may be different than 200 mV, since the overall calibration affects OPTIC TEST. Also if the SO_2 concentration display is not within the nominal range of 200 ± 20 PPM, the lamp ratio may need to be updated. See Section 10.1.6 for factory calibration procedure.

10.1.3.4 Analog Out Step Test

The Step Test is used to test the functioning of the 4 DAC outputs on the V/F board. The test consists of stepping each analog output 0-20-40-60-80-100% of the output. If the analog outputs are set for 0-5 V full scale the outputs would step 0-1-2-3-4-5 VDC. The stepping can be halted at any value by pressing the key under the percentage on the front panel. When the test is halted, square brackets are placed around the percentage value in the display. Pressing the key again resumes the test. This test is useful for testing the accuracy/linearity of the analog outputs.

10.1.3.5 DAC Calibration

The Digital to Analog Converters (DAC) are calibrated when the instrument is set up at the factory. Re-calibration is usually not necessary, but is provided here in case the V/F board needs to be replaced and re-calibrated. The procedure for using the DAC Calibration routines are in the Troubleshooting Section 10.3.2.1.

10.1.3.6 RS-232 Port Test

This test is used to verify the operation of the RS-232 port. When started, it outputs the ASCII letter X for about 2 seconds. During the test it should be possible to detect the presence of the signal with a DVM. A detailed procedure is given in the Section 4.3.1.2.

10.1.4 M100AH Internal Variables

The M100AH software contains many adjustable parameters. Many of the parameters are set at time of manufacture and do not need to be adjusted for the lifetime of the instrument. It is possible to change these variables either through the RS-232 port or the front panel. **Altering the values of many of the variables, especially those not listed on Table 10-5, will adversely affect the performance of the instrument.** Therefore it is recommended that these variables not be adjusted unless you have a clear understanding of the effects of the change.

Table 10-5 contains a description of "easy variables" which do not require special password from the front panel. "Hard variables" require special password and contact factory if you need to adjust them. "V LIST" of RS-232 will list all the variables except those that should never be manually edited.

To access the VARS menu press SETUP-MORE-VARS-ENTR. Use the PREV-NEXT button to select the variable of interest and press EDIT to examine/change the value, then press ENTR to save the new value. If no change is required, press EXIT.

Table 10-5: Model 100AH Variables

No.	Name	Units	Default Value	Value Range	Description
0.	DAS_HOLD_ OFF	MIN	15.0	0.5-20.0	Hold off duration after calibration or diagnostic mode.
1.	TPC_ENABLE		ON	ON-OFF	Temp/Pres compensation enable
2.	RCELL_SET	°C	50	30-70	Reaction cell temperature set point
3.	DYN_ZERO		OFF	OFF/ON	Enable to adjust zero calibration through remote contact closure
4.	DYN_SPAN		OFF	OFF/ON	Enable to adjust span calibration through remote contact closure
5.	RS232_MODE	Bit Field	8	0-99999	Value is SUM of following decimal numbers: 1=enable quiet mode 2=enable computer mode 4=enable security feature 8=enable front panel RS-232 menus (Teledyne API protocol) 16=enable alternate protocol (i.e. Hessen) 32=enables multi-drop support
6.	CLOCK_ADJ	Sec.	0	±60	Real-time clock adjustment

10.1.5 Test Channel Analog Output

Many of the TEST functions have an analog voltage associated with them. As a diagnostic aid it is possible to route any one of the various test voltages out the 4th analog output port (see Figure 2-2). Table 10-6 lists the test measurements that may be routed to test channel output. To route an analog test measurement to test channel output, press SETUP-MORE-DIAG-ENTR and use the PREV or NEXT buttons to scroll to the TEST CHAN OUTPUT and press ENTR. Press the PREV or NEXT buttons to scroll to the desired measurement and press ENTR.

Table 10-6: Test Channel Output

#	Name	Description	Scaled Range
0	NONE		
1	PMT READING	PMT output	0 - 5000 mV
2	UV READING	UV lamp output	0 - 5000 mV
3	SAMPLE PRESS	Sample pressure sensor	0 - 40 in-Hg
4	SAMPLE FLOW	Sample flow rate	0 - 1000 cc/min.
5	RCELL TEMP	Reaction cell temp. sensor	0 - 70°C
6	CHASSIS TEMP	Inside of chassis temp. sensor	0 - 70°C
7	PMT TEMP	PMT temp. sensor	0 - 20°C
8	DCPS VOLTAGE	DC power supply	0 - 5000 mV
9	HVPS VOLTAGE	HV power supply sensor	0 - 1000 V

When a measurement other than NONE is selected, an additional test measurement appears on the display, which has the format "TEST=XXXXX.X MV" and shows the mV value currently being output to test analog output port.

10.1.6 Factory Calibration Procedure (Quick Cal)

This procedure is referred to in other Teledyne API instrument manuals as the "Quick Cal" procedure. It is used at the factory when the instrument is first set-up.

The Factory Cal procedure balances the PMT, Preamp, and software gain factors so the instrument has optimum noise, linearity, and dynamic range. It should be used when you are unable to zero or span the instrument, when the slope and offset values are outside of acceptable range, or when other more obvious reasons for problems have been eliminated.

NOTE

In this procedure a range of 500 PPM and a span gas concentration of 400 PPM is used as an example. Other values can be used.

PMT Calibration Procedure:

1. On the Preamp board, set S2 to 'B', set S1 to 2. Turn R19 25 turns counter-clockwise, then 12 turns clockwise. (see Figure 2-5)
2. Align the beam splitter assembly per Section 10.4.2.
3. Adjust the UV lamp per Section 10.4.2 and reset the Lamp Cal value by selecting SETUP-MORE-DIAG and scroll to select LAMP CALIBRATION. Reset the LAMP CAL value by pressing ENTR. Value displayed is the current UV lamp intensity and pressing ENTR will update the value.
4. Set RANGE MODE to SING by SETUP-RNGE-MODE to select single range operation.
5. Set the RANGE to 500 PPM by SETUP-RNGE-SET and key in 500, then press ENTR.
6. Input 400 PPM of SO_2 span gas in the sample inlet port.
7. Scroll to the PMT - TEST function.
8. In this example the expected span gas concentration is 400 PPM and therefore the expected voltage is about 3.5 V.
9. Adjust S2, the HVPS coarse adjustment, on the preamp board to the setting that produces a signal that is closest to 3.5 V. Adjust S1, the HVPS fine adjustment, to the setting that produces a signal that is closest to 3.5 V. Use R19 to trim the reading to 3.5 ± 0.1V.
10. Recalibrate the instrument for both zero and span to calculate the slope and offset (refer to Section 8). The above procedure is to assure that the instrument will operate with optimum noise, linearity, and dynamic range.

10.1.6.1 Electric Test (ET) Procedure

1. Any time the gain of the PMT buffer amplifier circuit (R19) is changed (refer component location label inside of the Preamp cover), that will change the ET reading. Since the gain was adjusted in the above procedure, do the following to re-adjust the ET signal.
2. To re-adjust ET press SETUP-MORE-DIAG, then scroll to ELEC TEST and press ENTR.
3. Scroll the TEST functions until PMT is displayed.
4. Adjust R27 until 2000 mV ± 50 is displayed.
5. Press EXIT to return to SAMPLE mode.

10.1.6.2 Optic Test (OT) Procedure

1. Any time the PMT buffer amplifier circuit (R19) gain and/or the PMT high voltage setting is changed, the OT reading will also change. The PMT cal procedure changed both of these values.
2. To re-adjust OT press SETUP-MORE-DIAG, then scroll to OPTIC TEST and press ENTR.
3. Scroll the TEST functions until PMT is displayed.
4. Adjust R25 until 200 mV ± 20 is displayed.
5. Press EXIT to return to SAMPLE mode.

10.2 Performance Problems

When the response from a span check is outside the control limits, the cause for the drift should be determined, and corrective action should be taken. Some of the causes for drift are listed below:

1. Fluctuations in flow. Such as leaks or plugged orifices.
2. Lack of preventive maintenance.
3. Change in zero air source.
4. Change in span gas concentration.
   A. Zero air or ambient air leaking into span gas line.
   B. Cal gas tank exhaustion.
   C. Dirty particulate filter.

10.2.1 AC Power Check

1. Check that power is present at main line power input. Verify that correct voltage and frequency is present.
2. Check that the unit is plugged into a good socket. Analyzer must have 3-wire safety power input.
3. Check circuit breaker. Circuit breaker is part of the front panel power switch. It is set each time the instrument power is turned on. If there is an internal short causing a trip, the switch will automatically return to the OFF position when an attempt is made to turn it on.

10.2.2 Flow Check

1. Check TEST function VACUUM PRES reading about 6 IN-HG and SAMP FLOW - Should be 650 ± 60 cc/min.
2. Check that pump is running. Observe pump for proper operation.
3. Test that pump is producing vacuum by removing fitting at the inlet of the pump and checking for suction at fitting.
4. Check for analyzer flow.
5. Remove the 1/4" fitting from the rear panel of the analyzer sample filter assembly and plug the fitting with your finger and note the weak vacuum produced.
6. Check instrument inlet flow using separate flow meter and compare the flow rate to the SAMP FLOW reading. If the flow is lower than expected flow, then leak check the analyzer as described in Section 9.7. Check if the flow sensor is out of calibration (see Section 10.3.5) or the orifice is plugged.
7. If there is no leak and all above procedures can not correct flow rate reading, then calibrate the flow rate (see Section 10.3.5).

10.2.3 No Response to Sample Gas

1. Confirm general operation of analyzer.
   A. Check for AC Power, Section 10.2.1.
   B. Do flow checks, Section 10.2.2.
   C. Confirm that sample gas contains SO_2.
   D. Check UV lamp is on.
2. Check instrument electronics.

A. Do ELEC TEST (ET) procedure in DIAGNOSTIC menu Section 10.1.3.2.

B. Do OPTIC TEST (OT) procedure in the DIAGNOSTIC menu Section 10.1.3.3.

C. Check if UV LAMP reading of TEST function is greater than 350 mV.

If the M100AH passes ET and OT that means the instrument is capable of detecting light and processing the signal to produce a reading. Therefore, the problem is most likely in the pneumatics.

10.2.4 Negative Concentration Display

1. Mis-calibration. The 'zero' gas that was used to zero the M100AH contained some SO_2 gas - that is it had more SO_2 gas than that of the sample air. May also be caused by doing a zero calibration using ambient air.
2. Broken PMT temperature control circuit, causing high zero offset. Check PMT temperature which should be 7 ± 1°C.
3. Aging UV filter causing high stray light. Check STR. LGT reading of TEST function. It should be less than 100 PPM.
4. Check for light leak.

10.2.5 Excessive Noise

Common reasons for excessive noise are:

1. Leak in pneumatic system.
2. Light leak - check the sensor module with strong light.
3. HVPS noisy - see HVPS test procedure. See Section 10.3.9.
4. Defective electronic components on preamp board. - use optic test and electric test to check electronics, optics and observe noise.
5. Contamination of reaction cell and optical system - This can be wet air or impurities. This can be detected by high PMT readings with zero air as sample gas. Clean reaction cell as described in Section 9.5.
6. Broken PMT temperature control circuit. Check PMT TEMP - TEST function.
7. Mis-calibration. Check SLOPES in TEST function.
8. Too low UV lamp output. Should be higher than 600 mV. Replace the lamp if it is lower than this value.
9. High stray lights - UV filter is aging.
10. Reaction cell temperature is not stable.

10.2.6 Unstable Span

Common causes are:

1. Leak in pneumatic system.
2. Unstable UV lamp output - replace lamp.
3. Sample lines or sample filter dirty - clean or replace.
4. Plugged sample inlet orifice - clean with methanol and sonic cleaner.
5. Defective HVPS - use optic test and electric test to isolate the HVPS. See also Section 10.3.9 HVPS test procedure.
6. Bad or defective PMT detector - check Optic test.
7. Reaction cell temperature not stable - observe warning messages, or RCELL TEMP in TEST functions. Check diagnostic LED in Power Supply Module for normal cycling.
8. PMT temperature not stable - observe warning messages, or PMT TEMP in TEST functions.
9. Sample vent line too short, allowing room air to mix with span gas - line should be a minimum of 15" long.
10. Calibration gas source unstable.

10.2.7 Unstable Zero

Common causes are:

1. Leak in pneumatic system.
2. Light leak - check the sensor module with strong light.
3. Sample lines or sample filter dirty - clean or replace.
4. Zero gas source unstable - verify quality of zero air and the flow rate.

10.2.8 Inability to Span

If the SPAN button is not illuminated when attempting to span, that means the reading is outside of the software gain ranges allowed. In an analog instrument it would be the equivalent to the span pot hitting the maximum.

Here are some things to check:

1. Check the expected span concentration value in CAL-CONC, and compare this to the value of the calibrator span gas being input. They should be close.
2. Check ET (see Section 10.1.3.2) and OT (see Section 10.1.3.3) for a response on the PMT - TEST function.
3. If the above do not check out, perform the Factory Calibration Procedure Section 10.1.6.

10.2.9 Inability to Zero

If the ZERO button is not illuminated when attempting to zero, that means the reading is outside of the software gain ranges allowed. In an analog instrument it would be the equivalent to the zero pot hitting the maximum.

Here are some things to check:

1. Select the PMT - TEST function. With zero gas going into the instrument, the value should be less than 50 mV, typically 10 - 30 mV. If you are getting a high reading, the probable reasons are:
   A. Leak that admits gas containing SO_2.
   B. Contaminated reaction cell. Remove and clean cell.
   C. Light leak.
   D. Zero gas that isn't really zero. Make sure you're not trying to zero the analyzer with sample gas or span gas.

10.2.10 Non-Linear Response

Common causes are:

1. Leak in pneumatic system.
2. Calibration device in error - re-check flowrates and concentrations, especially at low concentrations.
3. Contamination in sample delivery system:
   A. Dirt in sample lines or reaction cell.
   B. Dilution air contains sample or span gas.
   C. Dirty particulate filter.
4. Back pressure on sample inlet.

10.2.11 Slow Response

1. Contaminated or dirty sample delivery pneumatics.
   A. Dirty/plugged sample filter or sample lines.
   B. Dirty reaction cell.
   C. Check leak.
2. Flow rate too low.
3. Wrong materials in contact with sample - use glass or Teflon.
4. Insufficient time allowed for purging lines upstream of analyzer.
5. Insufficient time allowed for SO_2 cal gas source to become stable or cal gas flow is too low.

10.2.12 Analog Output Doesn't Agree with Display Concentration

1. V/F board DAC's out of calibration. Do DAC calibration and Factory Calibration.
2. Analog outputs electrically loaded down causing voltage to sag. Could be due to input impedance of chart recorder or data logger being too low or improper grounding.

10.3 Electronic Subsystem Troubleshooting and Adjustments

10.3.1 Computer, Display, Keyboard

The purpose of this section is to determine if the computer subsystem electronics hardware are working properly. Assessment will make it the board level.

10.3.1.1 Front Panel Display

The front panel display is a 2 line by 40 character display. It has its own microprocessor to decode commands and display characters. It contains a self test feature. To test the display:

1. Turn off the power to the instrument.
2. Fold down the M100AH front panel.
3. Disconnect the 24 line flat ribbon cable (J2) that connects the computer parallel port to the keyboard.
4. Turn on the M100AH power switch.
5. Observe the front panel display. If the display successfully completes its power on self test, it will display a single underline character "_" in the left most character of the top line of the display. If this character is present, the display is working properly.
6. Turn off the power to the analyzer, and re-attach the 24 line cable to J2, and proceed to the next test.

10.3.1.2 Single Board Computer

The SBC40 is a full function computer designed for instrument control applications. It consists of a microprocessor, 2 serial and one parallel ports, standard bus interface, and 4 sockets for memory. The memory sockets consist of: 256k ROM containing the multitasking operating system and application code, 32k E^2PROM containing the setup variables, 256k RAM containing data collected by the instrument, and a time-of-day clock to provide event timing services. The overall function of this board is quite complex. Complete testing of this board's functions is not possible in the field. If component level troubleshooting of this board is necessary, contact the factory for schematics.

Like the display, the overall functioning of the CPU can be confirmed by a simple test.

1. Locate the CPU board on the mother board by referring to Figure 2-5.
2. Power on the instrument.
3. Locate the red LED at the top left edge of the board.
4. It should be flashing at a frequency of about once per second.
5. This flashing indicates the board is powered up and is executing instructions.

RS-232 diagnostic procedures are described in Section 4.3.1.2. It is possible for the UART driver chip to malfunction in either or both of the input or output ports.

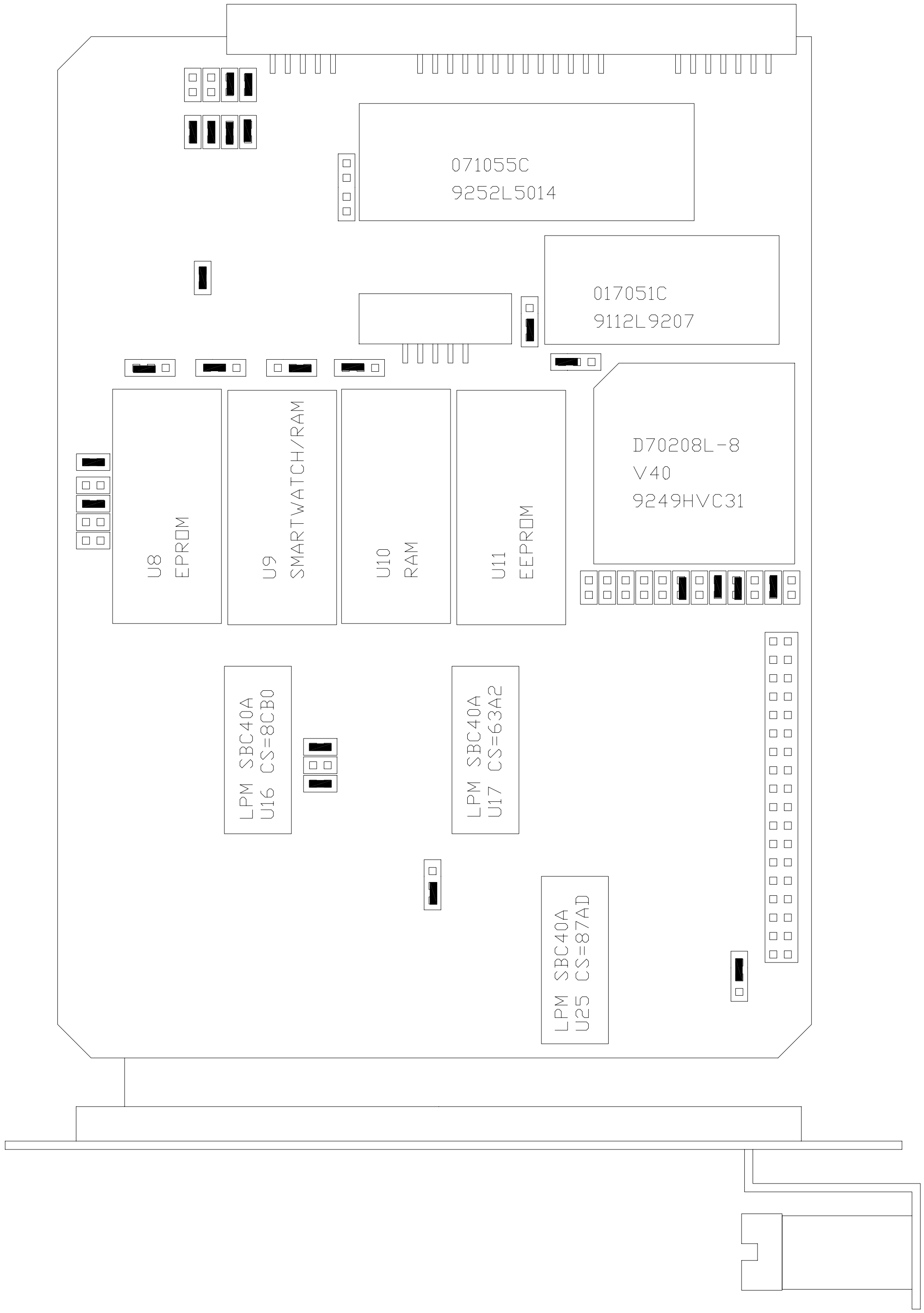


Figure 10-1: CPU Board Jumper Settings

10.3.1.3 Front Panel Keyboard

The keyboard consists of 8 keys and 3 LED's. Key strokes are sent to the SBC40 computer's parallel port. The computer software detects the key strokes via interrupts. The bottom line of the display consists of 40 characters which is divided into 8 - 5 character fields. Each field defines the function of the key immediately below it. The definition of the keys is variable and depends on the menu level of the software.

To check the operation of the keyboard, each key should perform an operation indicated by its current definition shown on the second line of the display.

Example #1 - testing key#1 (left most key).

At the top level menu key #1 is defined as the TEST function. Pressing this key should cause the middle field of the top line of the display to show the various test functions.

Example #2 - testing key #8 (right most key). At the top level menu key #8 is defined as the SETUP key. Pressing key #8 should cause the SETUP menu to be displayed.

Example #3 - If the 5 character field above any key is blank, the key is not defined, pressing the key has no effect.

The 3 status LED's indicate several functional states of the instrument such as calibration, fault, and sample modes. The state of the LED's is controlled by 3 lines on the parallel port of the SBC40. Functioning of the LED's can be checked by:

1. Turn off the M100AH power.
2. While watching the LED's, turn on the instrument power.
3. When the power comes up, the computer momentarily applies power to all 3 LED's for approximately 1 sec. If all the LED's are observed to light, they are working properly.

10.3.2 Voltage/Frequency (V/F) Board

The V/F Board consists of 16 analog input channels, each software addressable; 8 digital inputs, and 24 digital outputs, each line independently addressable; and 4 independent analog output channels. The analog input channels are connected to V/F converter capable of 80,000 counts, which is approximately 16 bit resolution. The integration period is software selectable from 40msec to 2.4 sec. Commands from the SBC40 computer and digitized values from the V/F section of the board are sent via the STD bus interface. The schematic for the board is in the Appendix 00514.

The overall operation of this board is quite complex. To fully check out all of its operational modes in the field is not recommended. Therefore, a few of simple tests are described here that test one analog input channel, the 4 analog output channels, one digital input, and one digital output.

1. V/F board analog input test.

   Each analog channel is routed through a programmable 16 channel multiplexer. If one channel works, chances are they all work.

   A. Turn on instrument.

   B. Press TEST key on front panel keyboard until DCPS test is displayed.

   C. The value displayed should read 2500 ± 100 mV

      If the M100AH passes this test, it has successfully digitized a 2500 mV composite voltage output from the Power Supply Module. The signal should also be quiet ± 25 mV.

2. Analog output channel test.

   In the DIAGNOSTIC menu on the front panel, there is a test that outputs a step voltage to the 4 analog outputs. This test is useful for calibrating chart recorders and dataloggers attached to the M100AH. The test can also be useful in diagnosing faults in the V/F board.

   A. Turn on the instrument.

   B. Enter the SETUP-MORE-DIAG menu.

   C. Scroll to select the ANALOG OUTPUT test. This causes the M100AH to output a 5 step voltage pattern to the 4 analog outputs on the rear panel. The status of the test is shown on the front panel display. The scrolling can be stopped at any voltage by pressing the key below the changing percentage display. The values are 0-20-40-60-80-100% of whatever voltage range has been selected. For example the voltages would be 0, 1, 2, 3, 4, 5 V if the 5 V range had been selected.

D. Use a DVM on each analog output channel to confirm the correct voltages.

If the voltages step, but are the wrong values, the V/F board may be out of calibration. See Section 10.3.2.1 for information on how to calibrate the V/F board.

3. Digital input channel test.

The digital I/O section of the V/F board has 8 input bits and 24 output bits. Two of the 8 input bits are assigned as calibration controls. See Section 8.5 for information on calibration using external contact closures.

To test the digital inputs:

A. Turn on the M100AH power on.

B. Connect a jumper wire across REMOTE IN terminals 1 and 2 of the rear panel connector as shown in Figure 2-2.

C. Shortly after closure is made the instrument should switch into zero mode as indicated on the front panel display.

D. Remove the jumper. Shortly after the jumper is removed the instrument should exit the zero calibrate mode and enter the HOLDOFF mode. To exit the HOLDOFF mode press EXIT, which will return the instrument to the SAMPLE mode.

4. Digital output channel test.

There are 24 output bits on the V/F board. The 24 bits are made up of three 8 bit ports. It is possible for a single 8 bit port or even a single bit within a port to fail.

A quick observational test of the digital outputs is to observe the LED's in the Power Supply Module (Refer to Figure 10-3 for the location of the LED's in the PSM). A more detailed test is in the DIAGNOSTIC menu. See Diagnostic tests in Section 10.1.3.

10.3.2.1 ADC/DAC Calibration Procedure

Due to the stability of modern electronics this procedure should not have to be performed more than once a year or whenever a major sub-assembly is exchanged or whenever analog output voltage range is changed. To calibrate the 4-20 mA current option output, proceed to the second part of the procedure for the calibration of 4-20 mA current output. After this procedure is completed, a Factory Calibration Procedure should be performed per Section 10.1.6.

To calibrate the DAC's on the V/F board, do the following:

1. Press SETUP-MORE-DIAG-ENTR, then scroll down to the D/A CALIBRATION diagnostic mode, then press ENTR to start the calibration procedure.

   Press CFG-SET-VOLT-ENTR to define Voltage output of the corresponding Analog Output Channel. If necessary a recorder offset can be introduced into the analog output voltages. It is intended for recorders that cannot show slightly negative readings. It can also be used to bias the input to a datalogger to offset small external ground loop voltages that are sometimes present in monitoring systems. The recorder offset will bias both the recorder and DAS analog outputs. Enter offset value in mV as needed and press ENTR-EXIT.

2. Press ADC to start the calibration. The M100AH display will read "ADJUST ZERO A/D= XX.X mV", where XX.X mV is the target voltage that should be coming out the DAC # 0. Put the probe of a voltmeter (recommend to use 4 1/2 digits meter) on the recorder output terminals 1 and 2 on the M100AH rear panel. The value displayed on the front panel and the voltmeter reading should be the same (± 3 mV). If they are not, adjust the zero pot (R27) on the V/F board until the two values are the same (± 1 mV). Note that the voltmeter reading does not change while adjusting the zero pot (R27). When the voltmeter shows the same value (± 1 mV) as the value displayed on the front panel, press ENTR.

   DAC #0 is terminals 1 and 2 of the recorder output.

3. The M100AH display will now show a new voltage in the same format as above. This voltage will be about 90% of the full scale DAC output range. Now the value displayed on the front panel and the voltmeter reading should be same (± 3 mV). If they are not, adjust the gain pot (R31) on the V/F board until the two values are the same (± 3 mV). Press ENTR. The DAC #0 is now calibrated and will be used as a voltage reference for calibrating the ADC.

4. Next, the analyzer goes through a procedure that calibrates the other 3 DAC's. When completed press EXIT to return to upper level menus.

   Next setup is recommended to verify the quality of the ADC/DAC calibration.

5. Pressing SETUP-MORE-DIAG-ENTR-NEXT, and select ANALOG OUTPUT. Verify the quality of ADC/DAC calibration by measuring the test channel output voltage. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the % display to hold that value and will display within the square bracket ([%]). Press key once again to continue scrolling or press EXIT to terminate. The exact voltage values depend on the DIP switch settings on the analog output buffer amplifiers.

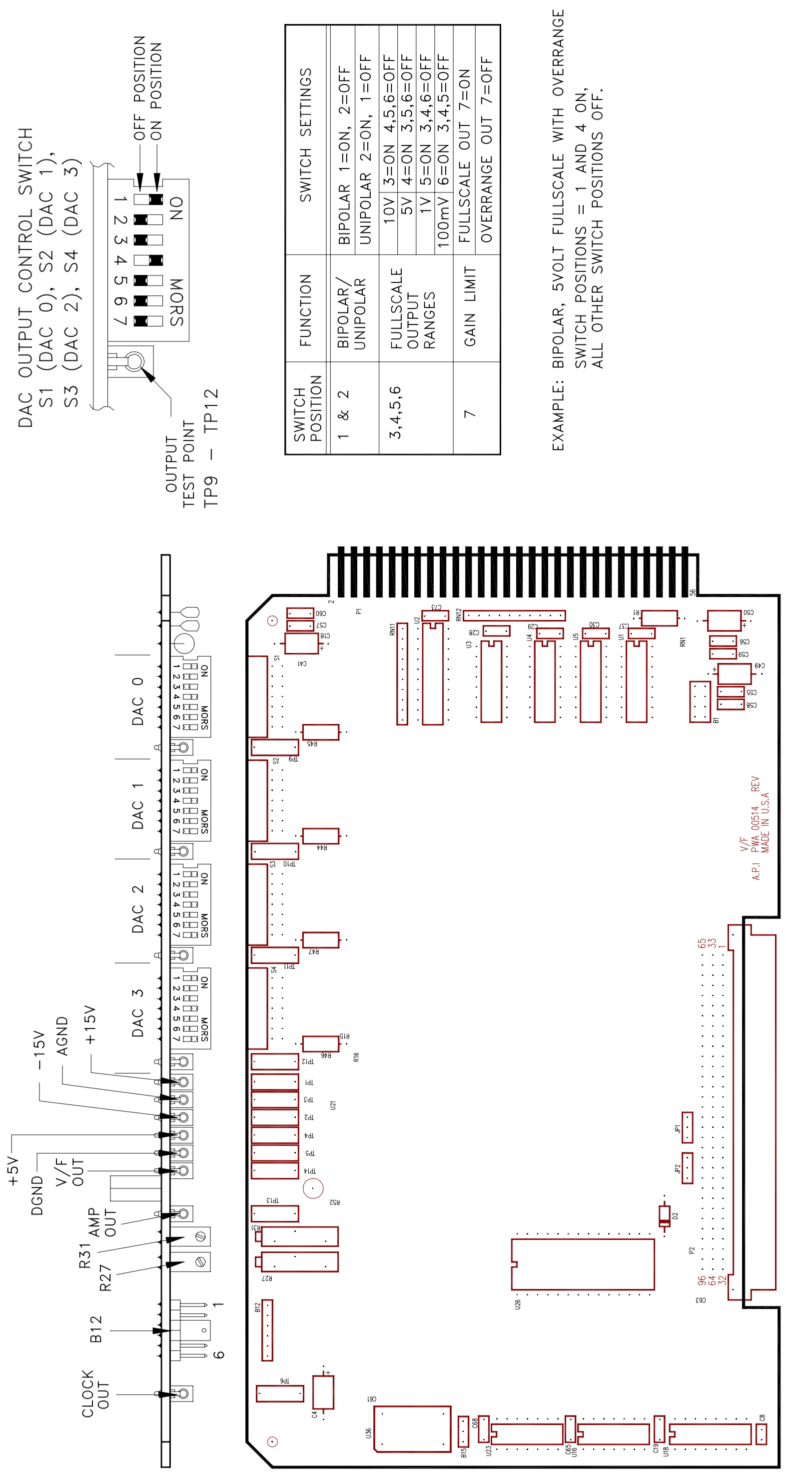
To calibrate the 4-20 mA current output option, do the following:

Verify ± 5 volt output DIP switch setting (refer to Figure 10-2) for 4-20 ma option before proceeding following procedure, since the input voltage of the 4-20 mA converter hardware is configured for 0-5 volt range.

1. Connect the 300 - 1000 ohm resistor to one of the 4-20 mA recorder output terminal 1 or 2 (refer to Figure 2-2). Connect in series the DC current meter between the resistor and other terminal of the recorder output with proper polarity.
2. Press SETUP-MORE-DIAG-ENTR and scroll down to the D/A CALIBRATION diagnostic mode, press ENTR to start the procedure. Press CFG and scroll by pressing NEXT to select desired current output channel, press SET-CURR-ENTR to define current output channel.
3. Press CAL to start the calibration. The M100AH display will read "x)CONC_OUT_X,CURR,ZERO", where X is the output channel number. Press the up/down buttons on the front panel until the current meter displays 4.0 mA (± 0.1mA). When the current meter shows a stable 4.0 ± 0.1 mA, press ENTR.
4. The M100AH display will now show "x)CONC_OUT_X,CURR,GAIN". As before, press the up/down buttons on the M100AH front panel until the current meter reads 20.0 ± 0.1 mA.
5. Repeat step 1 through 4 for additional current channel output calibration. Each current channel must be calibrated separately. When completed press EXIT to return to upper level menus.
6. Verify that the analog output is correct by performing SETUP-MORE-DIAG-ANALOG OUTPUT. The current meter should read 4, 7.2, 10.4, 13.6, 16.8, and 20 mA accordingly. See Section 10.3.3.4 for additional current output measurement methods.

10.3.2.2 Changing Output Voltage Ranges

If you are using analog voltage output, several different output voltage ranges can be selected by DIP switch setting on the V/F board. See Figure 9-3 for the DIP switch settings. **If you change the analog output voltage range, then you must reset the power of the instrument and do a ADC/DAC calibration per Section 10.3.2.1.**



SWITCH POSITION	FUNCTION	SWITCH SETTINGS
1 & 2	BIPOLAR/ UNIPOLAR	BIPOLAR 1=ON, 2=OFF UNIPOLAR 2=ON, 1=OFF
3,4,5,6	FULLSCALE OUTPUT RANGES	10V 3=ON 4,5,6=OFF 5V 4=ON 3,5,6=OFF 1V 5=ON 3,4,6=OFF 100mV 6=ON 3,4,5=OFF
7	GAIN LIMIT	FULLSCALE OUT 7=ON OVERRANGE OUT 7=OFF

Figure 10-2: V/F Board Dip Switch Settings

10.3.3 Status/Temp Board

The Status/Temp Board is a multifunction board that:

1. Converts the resistance readings of the thermistors to voltages
2. Provides status output circuitry
3. Provides circuitry for contact closure inputs
4. Provides circuitry for display brown-out/reset at low line voltage
5. Provides sockets for voltage-to-current modules

10.3.3.1 Temperature Amplifier Section

The Status/Temp board (01086) is a multifunction board consisting of 4 thermistor amplifiers that monitor:

1. Spare
2. Reaction Cell temperature
3. Box temperature
4. Spare

The voltages of the thermistor and thermocouple amplifier outputs are brought out to test points on the edge of the board. Refer to the schematic 01086 for details. The voltages can also be read using the DIAGNOSTIC - SIGNAL I/O feature (see Table 10-4 for details).

Thermistor Temperature Amplifier Adjustments

The Status/Temp board has 3 thermistor temperature amplifiers:

1. Reaction Cell Temperature
2. Spare
3. Box temperature readout

These 3 outputs are controlled by a common pot (R34) on the upper edge of the card.

If the temperature readouts are in error:

1. Adjust R34 of the Status/Temp board to read 2.577 VDC between test point 6 and test point 2.
2. This will cause all of the readouts to accurately measure their respective temperatures.

10.3.3.2 Display Brownout

During low AC line conditions the display can lock up due to insufficient voltage. When low line conditions are approaching, this circuit senses the condition by monitoring the un-regulated +5 VDC in the Power Supply Module. If brownout conditions are met, the DISP_BROWNOUT line is asserted and the CPU sends a hardware RESET command to the display and sends a BRNOUT RESET pulse back to U4. Brownout conditions will be noticed by the display flashing every 8 seconds.

10.3.3.3 Status Output Lines, External Contact Closures

The Status lines consist of 2 active input lines, and 12 active output lines. Additional circuits are present on the board but currently unused. Individual lines are set or cleared under CPU control depending on the assigned alarm condition. The CPU also monitors the 2 input lines for remote calibration commands. The status inputs and outputs are terminated at the rear panel. (See schematic diagram 01917, Figure 2-2 and Figure 4-3 for details.)

The output lines are opto-coupled NPN transistors which can pass 50 ma max of direct current with a voltage of 30 VDC max (see Schematic 01087).

The input lines are optically isolated with inputs pulled up to +5 VDC. External contacts can be contact closures or open channel transistor contacts. DO NOT apply any voltage, since +5 VDC is supplied internally (refer Figure 2-2 and Schematic 01087 for details).

Individual status lines can be set or cleared using the DIAGNOSTIC mode SIGNAL I/O. This can be useful for simulating fault conditions in the analyzer to see if external circuitry is working correctly. See Table 4-3 for pin assignments.

10.3.3.4 4-20 mA Current Output

4-20 mA current loop option replaces the voltage output of the instrument with 4-20 mA current output. The current outputs come out on the same terminals that were used for voltage outputs (see Figure 2-2). It is programmable for 4-20mA or 0-20mA and has a 1500 V common mode voltage isolation and 240 V RMS normal mode voltage protection. V_{loop} = 28 V max which is sufficient to drive up to a 1000 ohm load. Verify that the jumpers on the motherboard are set properly for the current output mode (refer to schematic 01087 and 01248). See Section 10.3.2.1 for the 4 - 20 mA current output calibration procedure.

There are two methods to measure the output of 4-20mA option.

1. Voltage method - preferred method

   Digital type Multi-meters (DMM) are ideally suited for this type of measurement because of their high input impedance - usually 10 M ohm or greater. The total load resistance should be between a 200ohm (min) to 1000 (max), precision load resistor of 0.1% tolerance or better is recommended.

2. Current method

   Although current is constant in a series circuit, accuracy in this type of measurement is usually less precise than with the voltage method due to the type of circuitry used in digital multi-meters. Connect a load resistance (between 200 - 1000 ohm) in series with the DMM.

10.3.4 Power Supply Module

The Power Supply Module consists of several subassemblies described in Table 10-7 below.

Table 10-7: Power Supply Module Subassemblies

Module	Description
Linear Power Supply Board	The linear power supply board takes multiple voltage inputs from the power transformer and produces +5, +15, -15, +12 VDC outputs. The outputs are routed to two external connectors, P2 and P3. See Figure 10-4. The +5 is used for operating the CPU. The ± 15 is used in several locations for running op-amps and IC's. The +12 is used for operating fans and valves.
Switching Power Supply	The switching power supply supplies +15 VDC at 4 A to the PMT cooler control on the Sensor Module. The output is made available through J10 on the Switch Board. There is a load resistor on the Switch Board to keep the output stable when little current is required from the supply.
Switch Board	The Switch Board has many different functions. It takes logic signals from the V/F board and uses them to switch 4-115 VAC and 4-12 VDC loads. The board also contains the instrument central grounding tie point. It distributes AC and DC power as needed. Connector J2 programs the power transformers to take 115, 220, or 240 VAC inputs
Power Transformers	There are potentially 2 input power transformers in the instrument. The multitap transformer T1 is in every M100AH and supplies input power for the Linear Power Supply board described above. A second transformer T2 is added if 220 or 240 VAC input is required. Input power selection is done via a programming connector P2 which provides the proper connections for either foreign or domestic power.
Circuit Breaker/Power Switch	The front panel contains a combination circuit breaker - input power switch. It is connected to the PSM through J6 on the Switch Board. If an overload is detected the switch goes to the OFF position. Switching the power back on resets the breaker also.

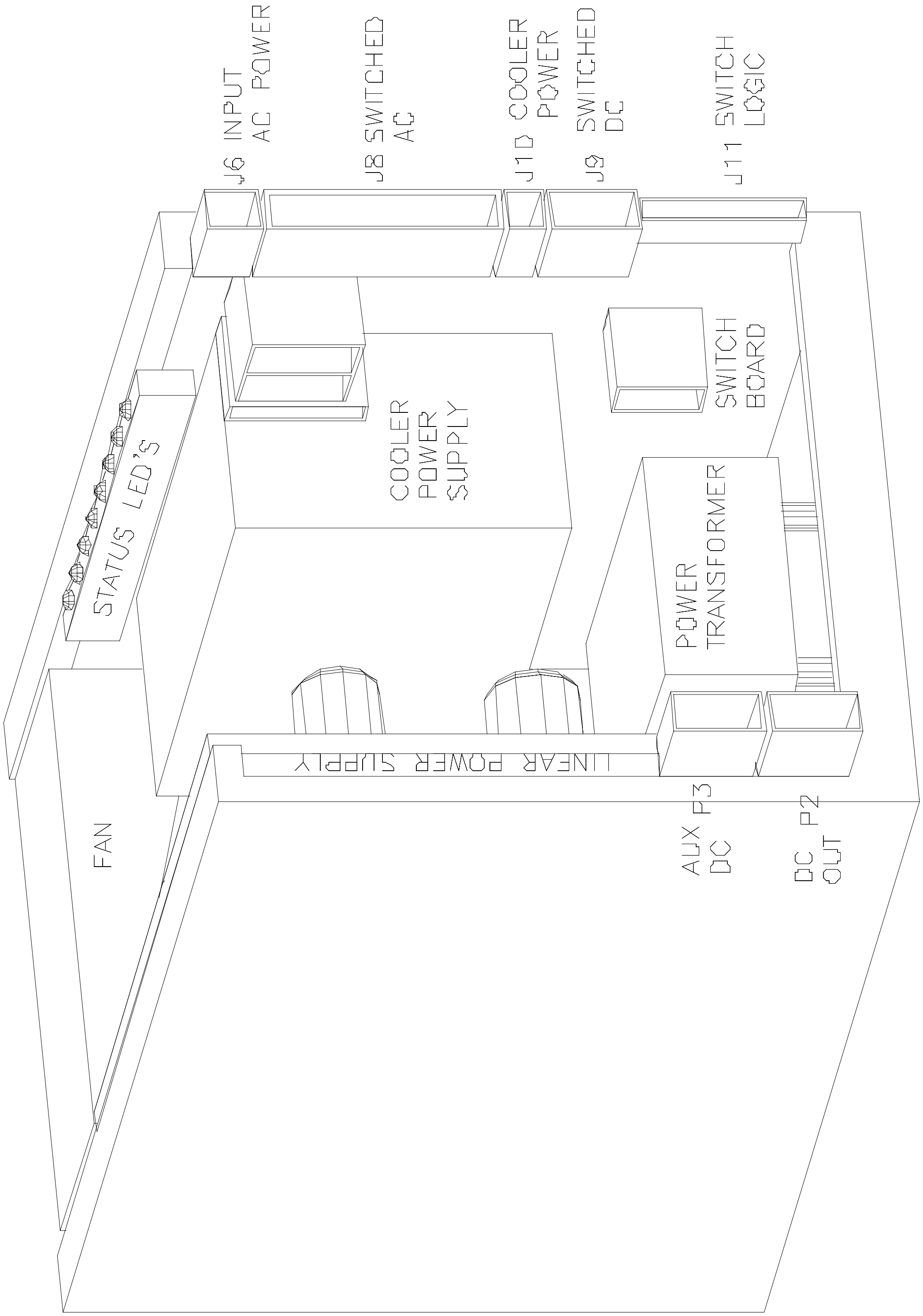


Figure 10-3: Power Supply Module Layout

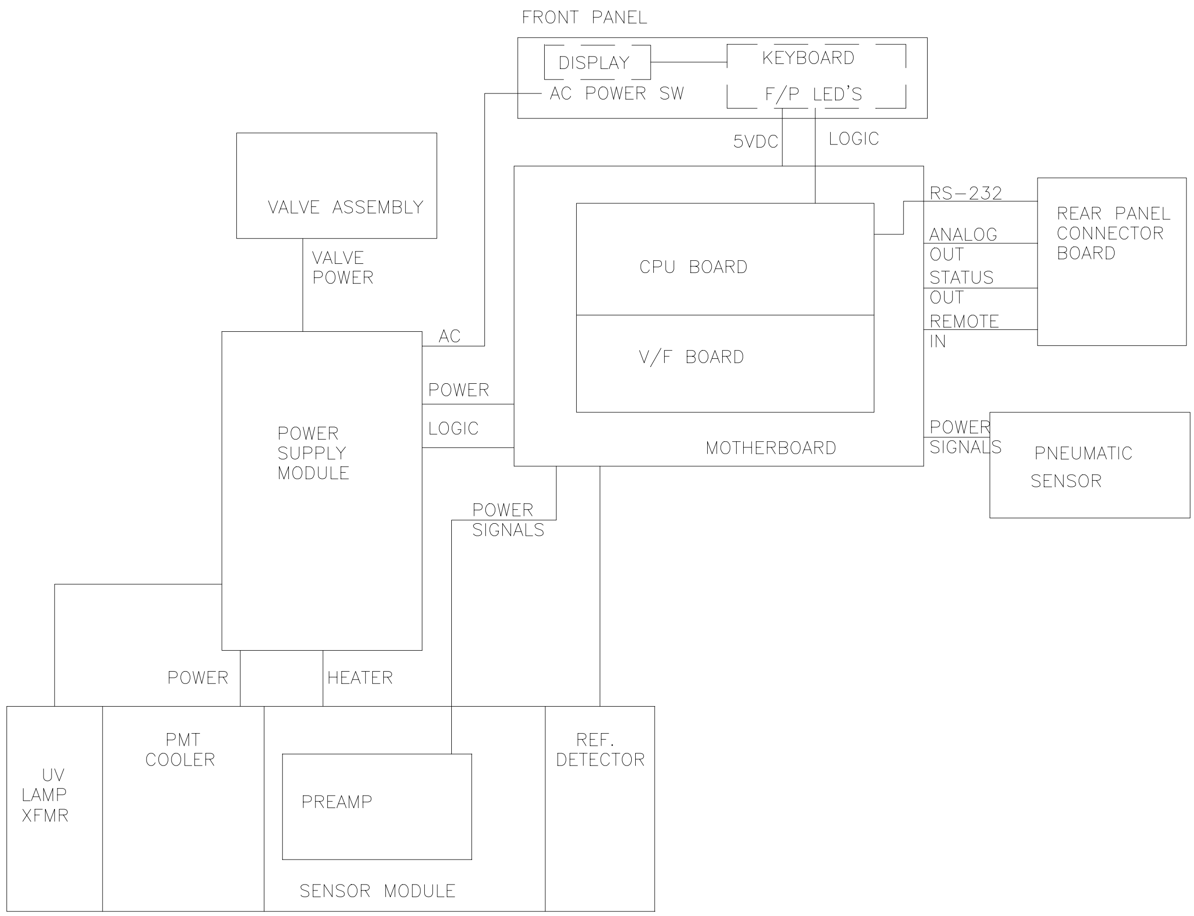


Figure 10-4: Electrical Block Diagram

10.3.4.1 PSM Diagnostic Procedures

The Linear Power Supply board can be tested by checking the DCPS - TEST function on the front panel. It should read 2500 mV ± 200 mV. If the value is outside this range, individual output voltages can be tested on connector P3, see Schematic in the Appendix for pinouts.

The Switching Power Supply output can be tested by observing the temperature of the PMT cold block using the PMT TEMP - TEST function. The temperature should be constant ± 1°C. The output voltage can be observed on J10 of the Switch Board. It should be 15VDC ± 0.5.

The Switch Board can be tested by observing the diagnostic LEDS along the top edge of the board. The following Table 10-8 describes the typical operation of each LED.

Table 10-8: Power Supply Module LED Operation

No.	Function	Description
1.	High Span Valve	Should switch ON when CALS-HIGH-ENTR button sequence pressed. High span gas input to analyzer.
2.	Zero Valve	Should switch ON when CALZ button pressed. Zero gas input to analyzer.
3.	Sample/Cal Valve	Should switch ON when CALS or CALZ buttons are pressed. ON when in calibrate mode.
4.	Low Span Valve	Should switch ON when CALS-LOW-ENTR button sequence pressed. High span gas input to analyzer.
5.	UV LAMP	Turns on the UV lamp power.
6.	Spare	
7.	Spare	
8.	Reaction Cell Heater	Should cycle ON-OFF every to control constant temp.

10.3.5 Flow/Pressure Sensor

The flow/pressure sensor board consists of 2 pressure sensors. See Figure 10-5 for a diagram of this assmebly. The flow rate value is computed from these two pressure sensors and displayed on the front panel TEST functions including two pressure readings. They are:

1. Inlet sample gas pressure - measured directly S1

2. Reaction cell pressure - measured directly S2

The above pressure and flow are filtered to produce the front panel readings. Several minutes may be required for a steady reading if observing the TEST functions.

Check Pressure

1. Remove the 1/8" fitting from the reaction cell and remove sample inlet tubing for the sample filter assembly.
2. Scroll to select VAC or PRES of the TEST functions.
3. Check if the pressure readings are close to the current absolute ambient pressure (typical value at sea level is 29.9 Hg-In). Notice that it must be absolute pressure reading. Check if both readings do not differ more than 2% from each other.

Pressure Calibration

1. Press SETUP-MORE-DIAG-ENTR and Scroll to select PRESSURE CALIBRATION-ENTR.
2. Enter the current absolute pressure value in In-Hg.

Check Flow Rate

To calibrate the sample flow, proceed as follows:

1. Scroll to select SAMP FL of the TEST functions.
2. Using independent flow meter verify the flow rate into the reaction cell.
3. If the actual flow differs more 10% of the displayed flow, proceed to flow calibration.

Flow Calibration

1. Press SETUP-MORE-DIAG-ENTR and Scroll to select FLOW CALIBRATION-ENTR.

2. Enter the actual flow value from the independent flow meter.

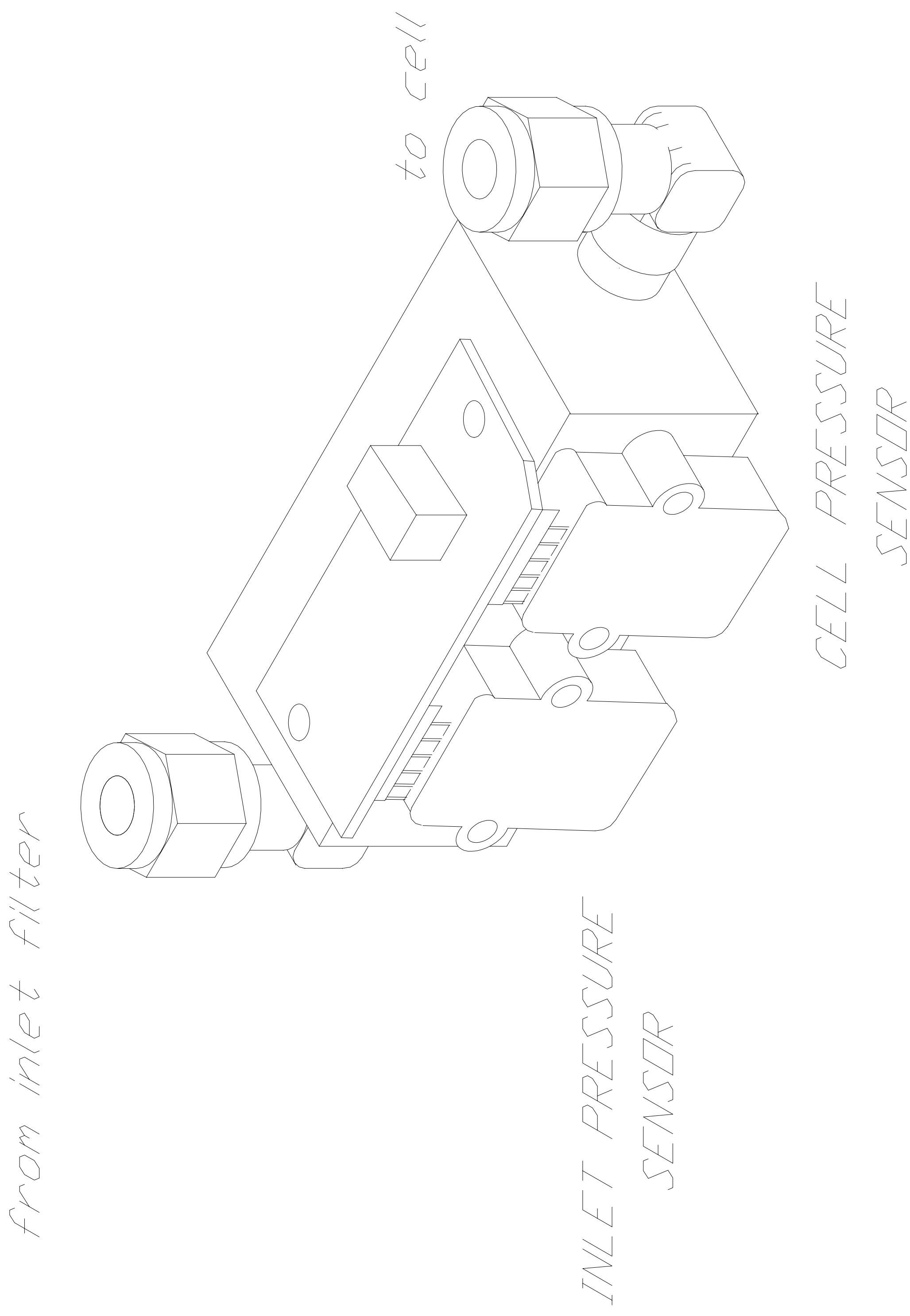


Figure 10-5: Pressure/Flow Sensor

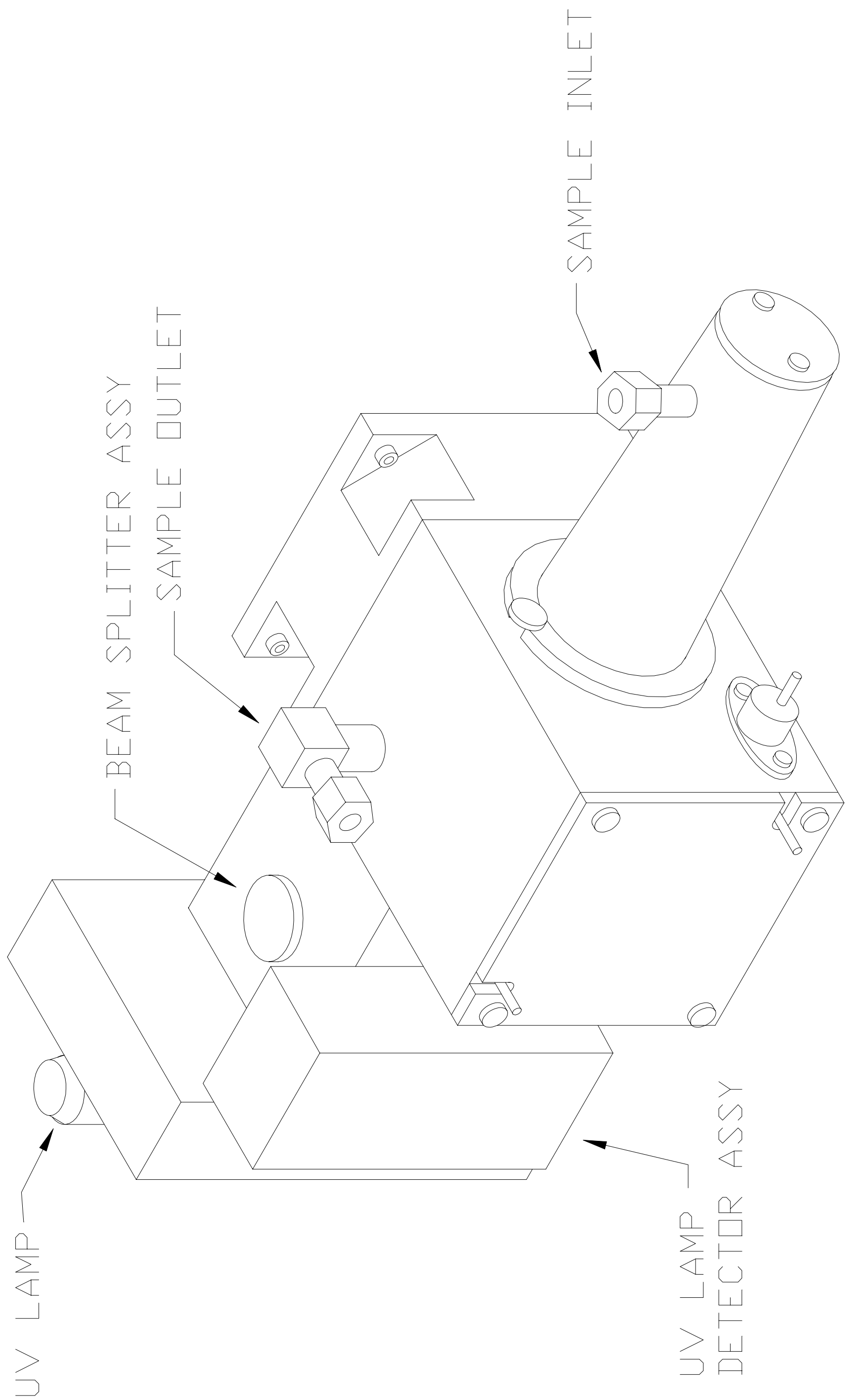


Figure 10-6: SO_2 Sensor Module

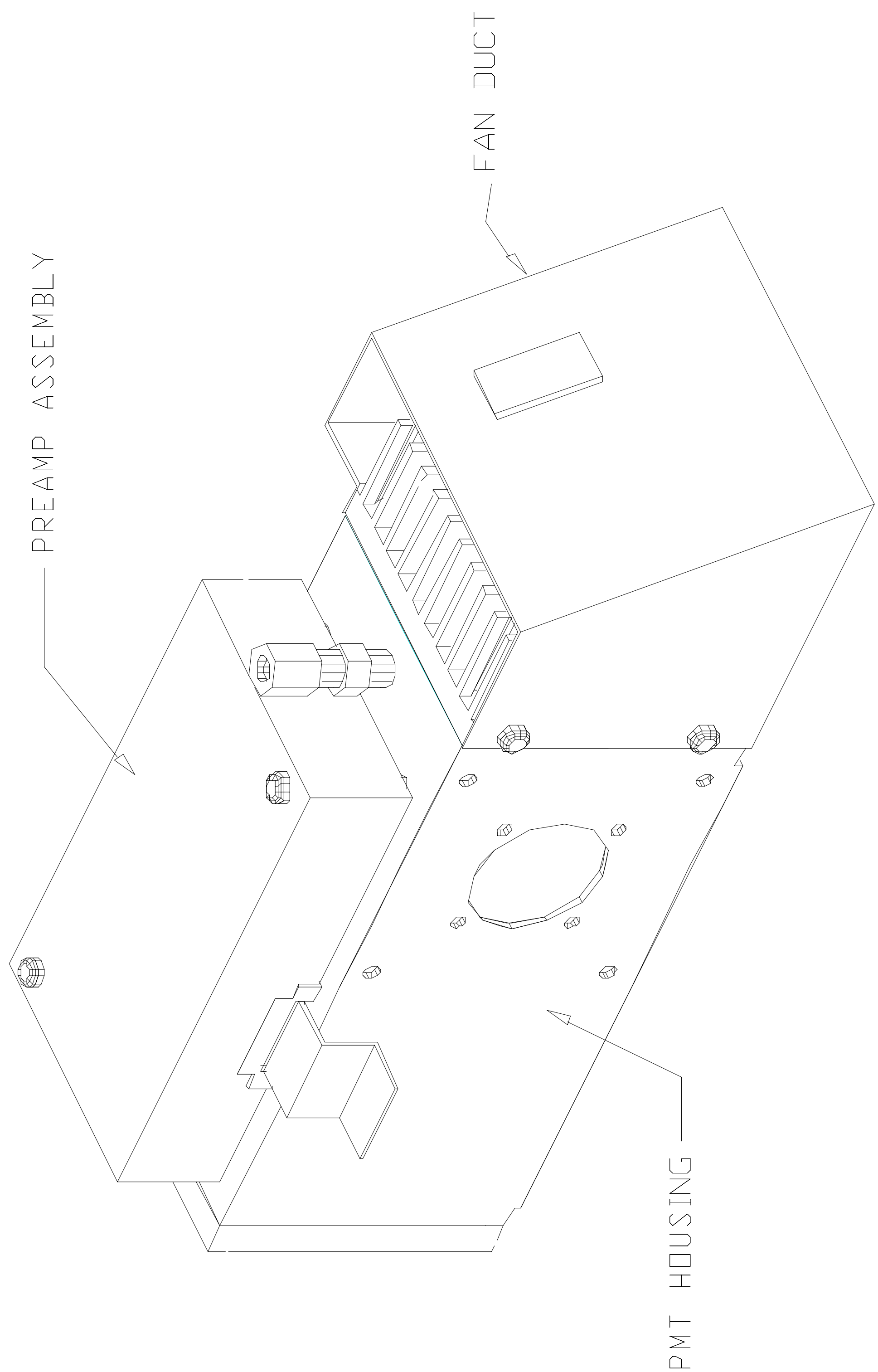


Figure 10-7: SO_2 Sensor Module

10.3.6 Reaction Cell Temp

The reaction cell temperature is controlled by the CPU using advanced algorithm to control constant temperature. It operates by reading a thermistor amplifier on the 01086 Status/Temp board. First LED from the front indicates the control power on-off status which can be seen from the cover of the PSM through the slot. A warning message is often present during initial warm-up due to the temperature being below the 50.0°C set point.

10.3.7 Preamp Board

The Preamp Board is a multifunction board providing circuitry to support the following functions.

1. Preamp, buffer amplifier, physical range control hardware for the PMT detector.
2. Precision voltage reference and voltage generation, and control for the PMT - HVPS inside the sensor module.
3. Constant current generator and adjustment for the Optic Test LED.
4. Voltage generation and adjustment for Electric Test.
5. Thermistor amplifier and temperature control circuit for the PMT cooler.

The setup and adjustment of items 1-4 above is covered in the Factory Calibration procedure in Section 10.1.6. Item 5 (see Section 10.3.9) is not adjustable.

10.3.8 PMT Cooler

The PMT cooler uses a Thermal Electric Cooler (TEC) supplied with DC current from the switching power supply in the Power Supply Module. An overall view is shown in Figure 10-8. The temperature is controlled by a temperature controller circuit located on the Preamp board. Voltages applied to the cooler element vary from 0.1 to 12 VDC. The input voltage from the supply is 15 VDC and LED indicates the presence of the voltage. Typical control voltage to the FET is about 4.5 VDC when PMT temperature is at the 7°C setpoint. At normal room temperatures the 7°C set point should be maintained within 0.1°C. These voltages can be measured from the PCB mounted in the fan shroud. The control voltage from the Preamp can be measured between TP18 and TP11 of the Preamp PCB. Also under normal room temperature and at the 7°C PMT set point the voltage between TP1 and TP2 will typically measure between 0.15 V - 0.2 V which translates to about 1.5-2 Amp DC current flowing through the Thermal Electric Cooler (TEC). Following procedures show how to replace the TEC assembly.

1. Remove three screws that hold the sensor assembly (Refer to Figure 2-1. They are located adjacent to the shipping screws).
2. Remove four screws that hold the fan duct and unplug cable plugs from the fan duct assembly.
3. Remove four screws holding the heatsink assembly from the PMT housing assembly and separate these two assembly carefully by pulling heatsink assembly slowly out of the PMT housing until HVPS module is completely out of the PMT housing (refer to Figure 10-8).
4. Remove two screws from the HVPS module to separate HVPS module from the cooler block.
5. Pull out PMT, LED, and thermistor carefully from the cooler block. Be careful not to contaminate the window of the PMT with thermal compound from the thermistor. The PMT is fragile, so handle carefully.
6. Replace two desiccant bags inside of the PMT housing with new bags.
7. Replace cooler assembly (P/N 01461) and assemble by reversing the above steps.

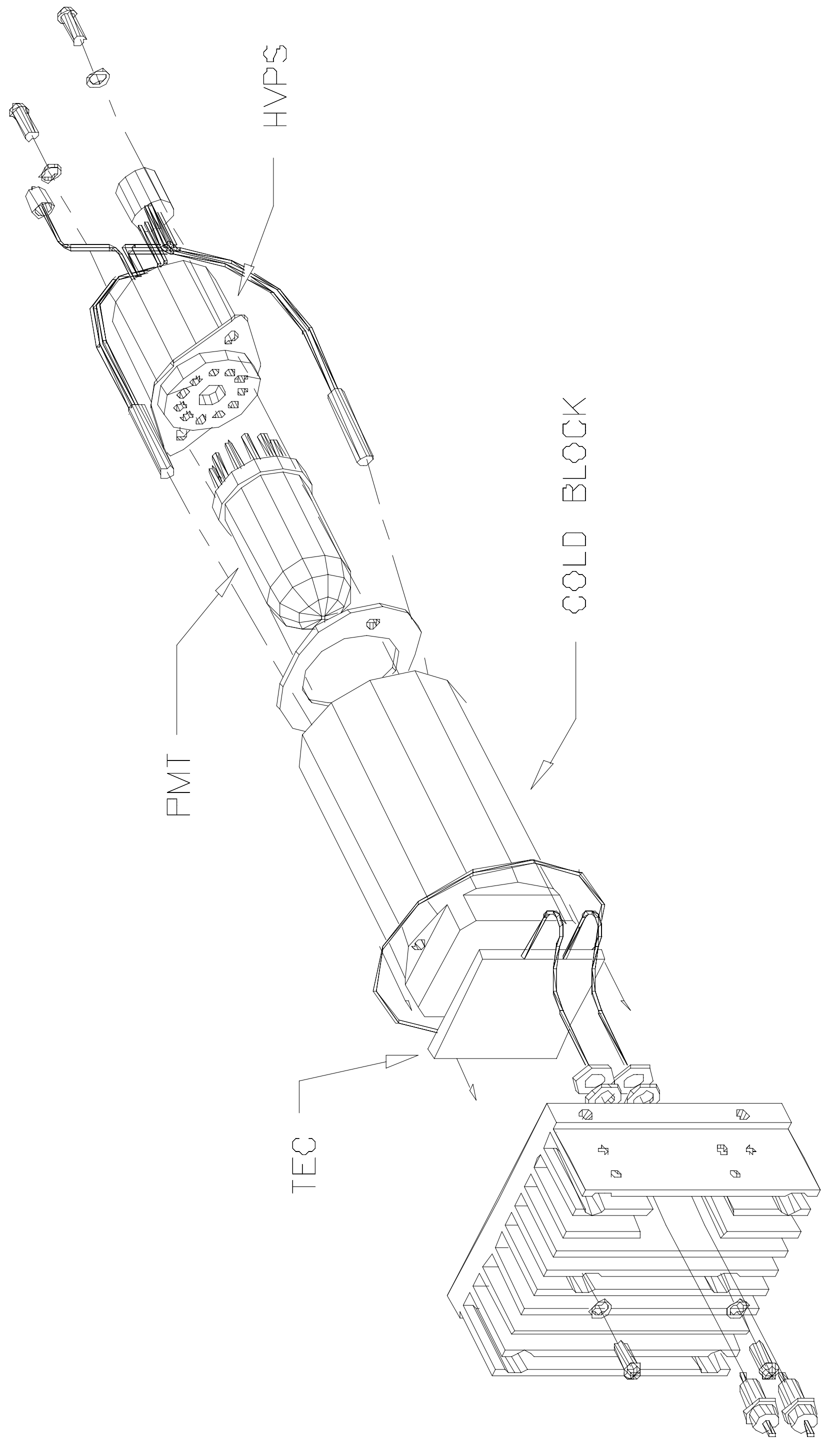


Figure 10-8: PMT Cooler Subsystem

10.3.9 HVPS (High Voltage Power Supply)

The HVPS is located in the interior of the Sensor Module, and is plugged into the PMT tube. It requires 2 voltage inputs. The first is +15 VDC which powers the supply. The second is the programming voltage that is generated on the Preamp Board. The test procedure below allows to test HVPS. Adjustment of the HVPS is covered in the Factory Calibration Procedure in Section 10.1.6.

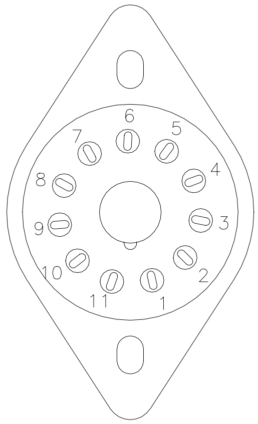
To troubleshoot the HVPS:

1. While sampling stable SO_2 gas, record PMT reading and HVPS reading of the TEST function.
2. Change HVPS voltage about 50V lower than the current setting by adjusting S2 and S1 on the preamp board. If PMT reading on the display drops about 40±10% from the previous reading, then HVPS is working properly.
3. If PMT reading does not drop , then do ELECTRIC test per Section 10.1.3.2.
4. If ELECTRIC test is working properly, then do OPTIC test per Section 10.1.3.3.

If all of the above are checked properly, then the problem is either the PMT or HVPS. Check the HVPS as follows

5. Turn off the instrument.
6. Remove the cover and disconnect the 2 connectors at the front of the SO_2 PMT housing.
7. Remove the end plate from the PMT housing.
8. Remove the HVPS/PMT assembly from the cold block inside the sensor. Unplug the PMT tube.
9. Re-connect the 7 pin connector to the Sensor end cap, and power-up the instrument.
10. Use Figure 10-9 to check the voltages at each pin of the supply, and the overall voltage.
11. Turn off the instrument power, and re-connect the PMT tube, then re-assemble the sensor.

If any faults are found in the test, you must obtain a new HVPS as there are no user serviceable parts inside the supply.



CAUTION

HIGH VOLTAGE PRESENT

To test the HVPS, follow the procedure outlined in Section 10.3.10 of the manual. Then:

1. With the instrument disassembled as described and the power turned on, check the HVPS – TEST function on the front panel.
2. Divide the observed HVPS voltage by 10 and test the following pairs of points. The voltage should be 1/10 of the HVPS voltage for each pair.

For Example: If the voltage was 500VDC, the voltage at each stage would be 50VDC.

HVPS PINS	VOLTAGE
11–1	70
1–2	70
2–3	70
3–4	70
4–5	70
5–6	70
6–7	70
7–8	70
8–9	70
9–10	70

3. Each stage should have the same voltage. If so the HVPS is working.

Figure 10-9: High Voltage Power Supply

10.4 Optical Sensor Module Troubleshooting

10.4.1 PMT

The PMT detects the light emitted by the secondary emission of the SO_2 molecules. It has very high gain and low noise to detect the weak light source optimally. It is not possible to test the detector outside of the instrument in the field. The best way to determine if the PMT is working is by using an Optic test. OT operation is described in Section 10.1.3.3.

The basic method to diagnose a PMT fault is to eliminate the other components using ET, OT and specific tests for other sub-assemblies.

10.4.2 UV Lamp Adjust or Replacement

As the UV lamp output changes, the SO_2 concentration will change. There are five main types of energy changes or fluctuations associated with the UV lamp:

1. Line voltage changes - UV lamp energy is directly proportional to the line voltage.
2. Lamp short term drift - Over a period of hours, the UV emitted from the lamp may increase or decrease slightly.
3. Lamp aging - Over a period of months, the UV energy will show a downward trend, usually 30% in the first 90 days, and then a slower rate, until the end of useful life of the lamp, 2-3 years nominally.
4. Lamp positioning - The physical alignment of the lamp in its holder (which is optimized by **PEAKING** the lamp, originally at the factory) may be disturbed.
5. Beam splitter out of alignment - beam splitter holder may be disturbed.

To adjust or to replace the UV lamp, proceed as follows:

1. Loosen the thumbscrew to allow the lamp to move freely. Replace the lamp if needed.
2. Slowly rotate or move the lamp vertically while monitoring the UV LAMP display to read 3500 mV ± 200 mV. If the UV lamp is lower than 3500 mV, then peak the lamp to get its maximum output.
3. Finger tighten the thumbscrew.
4. After adjusting the UV lamp intensity reset the Lamp Cal value by selecting SETUP-MORE-DIAG and scroll to select LAMP CALIBRATION. Reset the LAMP CAL value by pressing ENTR. The value displayed is the old UV lamp intensity and pressing ENTR will update with new value. Now the LAMP RATIO test reading should be 100%.
5. Calibrate Zero/Span of the Analyzer using calibration gas.

CAUTION

Strong UV light Present

Always use safety glasses (plastic glasses will not do)

If the UV LAMP display is lower than 600 mV after peak adjustment, it is recommended that the lamp be replacd. Most UV lamps with output above 600 mV are still in good condition. UV LAMP display below 350 mV will cause the instrument to display XXXXX.X.

To adjust the beam splitter assembly:

1. Loosen two screws of the beam splitter assembly. (Refer Figure 10-6)
2. While observing the test measurement value of UV LAMP display, rotate slowly to get maximum UV lamp reading.
3. Tighten two screws evenly little by little.

To replace the UV filter, proceed as followings:

1. Turn off the instrument’s power and remove the power cord from the instrument.
2. Unplug J4 connector from the motherboard to allow tool access.
3. Remove 4 screws from the lamp cover (refer to Figure 10-9) and remove the cover.
4. Remove 4 screws from the UV filter retainer.
5. Carefully remove the UV filter.
6. Install new UV filter. Handle carefully and do not touch the filter’s surface. UV filter’s wider ring side should be facing out.
7. Install UV filter retainer and tighten 4 screws.
8. Install the lamp cover. Tighten 4 screws.
9. Plug J4 connector into the motherboard.

10.5 Pneumatic System Troubleshooting

The pneumatic system is diagrammed in Figure 9-3 depending on which options the instrument was ordered with.

10.5.1 Leak Check

CAUTION

When doing a leak check do not pressurize the M100AH to greater than 15 psig. Damage to internal components will occur at higher pressures.

Many performance problems are caused by leaks. Refer to Section 9.7 for the leak check procedure.

10.5.2 Pump

The external vacuum pump is capable of 14"Hg Absolute pressure at 1 SLPM or better to maintain critical flow. If the vacuum pressure reading noted is higher than 10"HG, the pump may need servicing. A pneumatic leak also can cause higher pressure reading.

10.5.3 Z/S Valves

The Z/S Valves is an option in the instrument. Before troubleshooting this sub-assembly, check that the options were ordered, and that they are enabled in the software (if not call factory).

Check for the Z/S valves:

1. Check for the physical presence of the valves. See Figure 2-5 for Z/S Valve location.
2. Check front panel for option presence. The front panel display when the instrument is in SAMPLE more should display CALS and CALZ buttons on the second line of the display. The presence of the buttons indicates that the option has been enabled in software.

Troubleshooting the Z/S valves:

1. It is possible to manually toggle each of the valves in the DIAGNOSTIC mode. Refer to Section 10.1.3 for information on using the DIAG mode. Also refer to Figure 9-3 for a pneumatic diagram of the system.
2. Plug the corresponding inlet port on the rear panel with your finger and feel the weak vacuum produced. If not, check LED on the power supply module (refer to Table 10-8) for valve switching.

11 M100AH SPARE PARTS LIST

Note: Use of replacement parts other than those supplied by Teledyne API may result in non-compliance with European Standard EN61010-1.

Table 11-1: Teledyne API M100AH Spare Parts List

Part No.	Description
00094-8	ORIFICE, 12 MIL, 650 CC, Rx CELL
00262-01	UV LAMP ASSY
00270	LENS, UV
00269	LENS, PMT
00271	UV FILTER
00274	PMT OPTICAL FILTER
00276-4	CPU BOARD
00329	THERMISTOR ASSY
00337	HEATER/THERMISTOR ASSY (Rx CELL)
00484	UV TRANSFORMER ASSY, 60Hz
00484-1	UV TRANSFORMER ASSY, 50Hz
0051402	V/F BOARD
00596	ACTIVATED CHARCOAL
00704	KEYBOARD
00728	DISPLAY
00969	FILTER, TFE, 47 MM, QTY 100
00969-1	FILTER, TFE, 47 MM, QTY 25
0108600	STATUS/TEMP BOARD
01105-1	PMT PREAMP BOARD ASSY
01139	ASSY, POWER SUPPLY MODULE - 115V/60Hz
01139-02	ASSY, POWER SUPPLY MODULE - 220V/50Hz
01139-04	ASSY, POWER SUPPLY MODULE - 240V/50Hz
01236	FAN, POWER SUPPLY MODULE
01314	FAN, PMT COOLER

(table continued)

Table 11-1: Teledyne API M100AH Spare Parts List (Continued)

Part No.	Description
01324	SO_2 SENSOR ASSY
01340	PMT, M100A SO_2
01357	THERMISTOR ASSY (COOLER)
01408-1	ASSY, HVPS
01461	COOLER ASSEMBLY
01474-02	M100AH 47 MM FILTER EXPENDABLES KIT
01930	KEYBOARD
02230	DC POWER SUPPLY BOARD
02417	INSTRUCTION MANUAL FOR M100AH
FL001	SINTERED SS FILTER
HW090	SPRING, SS, LONG
HW120	SHOCKMOUNT, SENSOR
OP012	UV DETECTOR
OR001	ORING, FLOW CONTROL
OR004	ORING, LIGHT TRAP
OR006	ORING, LENS HOUSING
OR007	ORING, PMT HOUSING/COVER
OR013	ORING, UV DETECTOR
OR015	ORING, PMT FILTER
OR016	ORING, UV LENS
OR042	ORING, SENSOR ASSY
PS004	POWER SUPPLY, SWITCHING
PU011	PUMP REBUILD KIT, THOMAS
RL008	SOLID STATE RELAY, 12 VDC
SW006	OVERHEAT SW, CELL/OVEN
TU001	TUBING: 6’, 1/8” CLR
TU002	TUBING: 6’, 1/8”, BLK

11.1 Model 100AH Level 1 Spares Kit

Table 11-2: Teledyne API M100AH Level 1 Spares Kit

Part No.	Description	
02456	M100AH LEVEL 1 SPARES KIT	
Includes:`		**Qty**
00262-01	UV LAMP ASSY	1
02418	UV FILTER	1
01340	PMT, M100A SO_2	1
01461	COOLER ASSEMBLY	1
HW144	SHOCKMOUNT, SENSOR	3
OP012	UV DETECTOR	1
PS002	HVPS	1
PU011	PUMP REBUILD KIT, THOMAS	1
RL008	SOLID STATE RELAY, 12 VDC	1
00596	ACTIVATED CHARCOAL	1

Table 11-3: Teledyne API M100AH 47 mm Expendables Kit

Part No.	Description	
02455	M100AH 47 MM FILTER EXPENDABLES KIT	
Includes:`		**Qty**
00969-01	FILTER, TFE, 47 MM, QTY 25	2
FL001	SINTERED SS FILTER	1
HW020	SPRING, FLOW CONTROL	1
OR001	ORING, FLOW CONTROL	2
00596	ACTIVATED CHARCOAL	1

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APPENDIX A MAINTENANCE SCHEDULE FOR M100AH

DATE INSTRUMENT RECEIVED ______________													
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
PARTICULATE FILTER ELEMENT													REPLACE WEEKLY AS NEEDED
PUMP CHARCOAL SCRUBBER													REPLACE QUARTERLY
DFU PARTICULATE FILTER FOR SCRUBBER													REPLACE ANNUALLY
PNEUMATIC LINES													EXAMINE AND REPLACE AS NECESSARY
LEAK CHECK AND QUICK CAL													CHECK ANNUALLY. SEE SECTION IN MANUAL. LEAK CHECK AFTER ANY MAINTENANCE THEN FOLLOW QUICK CAL.
PUMP DIAPHRAGMS													EVERY 12 MONTHS
SAMPLE ORIFICE													REPLACE O-RINGS AND FILTER ANNUALLY
SAMPLE FLOW													CHECK FOR PROPER FLOW 650 ± 10% CC/MIN. ANNUALLY

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APPENDIX B ELECTRICAL SCHEMATICS

Part Number	Name
00514	V/F Board Assembly
00515	V/F Board Schematic
0108601	Status/Temp Assembly
01087	Status/Temp Schematic
0113911	Power Supply Wiring Diagram
01248	Motherboard Assembly
01249	Motherboard Schematic
0131103	Reference Preamp Assembly
0131203	Reference Preamp Schematic
01471	Isolated 4-20 mA Output
01839	TEC Control PCB Assembly
01840	TEC Control PCB Schematic
01916	Connector Board Assembly
01917	Connector Board Schematic
01930	Keyboard Assembly
01931	Keyboard Schematic
02106	‘A’ Series Preamp Design
02107	Preamp Board Assembly
02108	Preamp Board Schematic
02222	Switch Board Assembly
02223	Switch Board Schematic
02230	DC Power Supply Assembly
02231	DC Power Supply Schematic

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